JANUARY 21, 1960

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY

Testing at High Heat Rates

Contents Page 3

This is a new HiLube® sintered bronze bearing. **It is treated with moly sulfide, is self-lubricating, and holds almost a third more oil than other sintered bronze bearings. It runs cool and quiet at high speeds. It will last far longer than any other bearing of its kind. HiLube is one of many special bearing materials developed by Bound Brook.**

Circle 401 on Page 19

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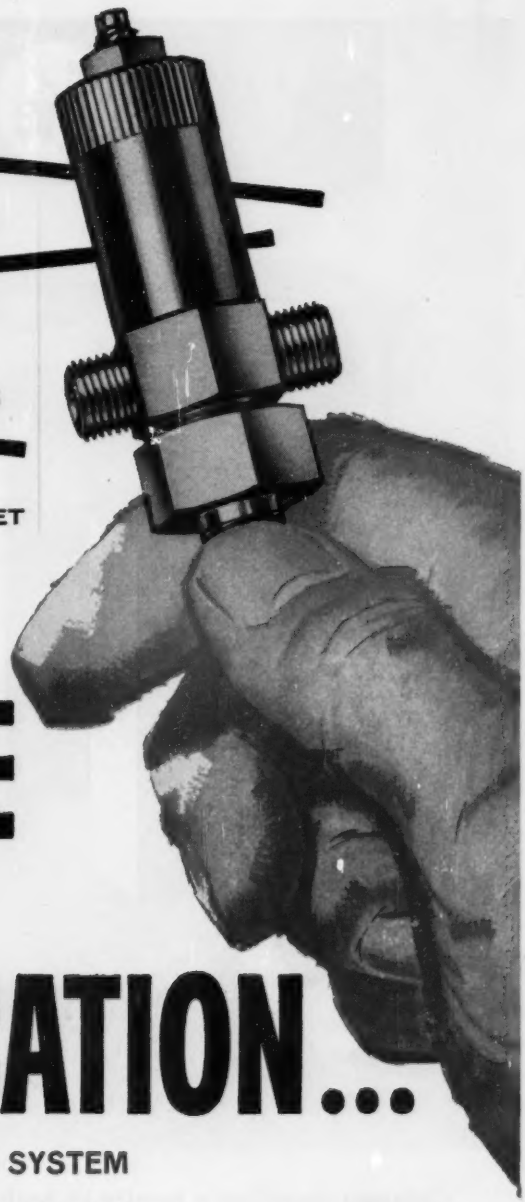

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While you're in the design stage—remember that no machine, no matter how simple or complicated its function, is really modern unless it is equipped with an automatic lubrication system.

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AN ACCUMATIC SYSTEM OFFERS ALL THESE ADVANTAGES:

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- No parts are neglected—lubricates inaccessible and dangerous bearings.
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- Services all bearings in one operation.
- Delivers exact amount of lubricant to bearing.

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STEWART-WARNER CORPORATION

Circle 404 on Page 19

Chicago Rawhide's family of high temperature chemically resistive materials that will seal almost anything, resist almost everything!

The brand name Sirvon represents any of several broad temperature range materials that are virtually inert, chemically . . . such as "TFE"* resins, Kel-F† resins, etc. However, there is an important difference in Sirvon. C/R compounders have dramatically improved the physical properties by blending with certain additives, and by the development of special production techniques. Here, briefly are a few typical properties:

TEMPERATURE RANGE: -320° to 500° F.

CHEMICAL RESISTANCE: Inert to all fluids and gases except flourine and molten alkali metals.

FRICTIONAL VALUES: Coefficients of friction as low as .016 (static) and 0.04 (dynamic).

SHORE DUROMETER: From 55 to 73 (D Scale) depending on additive material used.

ABRASION RESISTANCE: Dry bearing test — as little as 0.00005 in. per million rpm on ½-in. shaft. Temperature 100° F.; rpm 156; bearing pressure 120 psi.

The practical solutions to many design problems may be found with these new, specially compounded materials. If you are looking for shaft seals, sealing rings, bearings, packings or gaskets that require unusually low friction, extreme temperature and chemical resistance, consult with C/R sales engineers.

Write for C/R Sirvon Bulletin SR-101 for more information on properties and applications.

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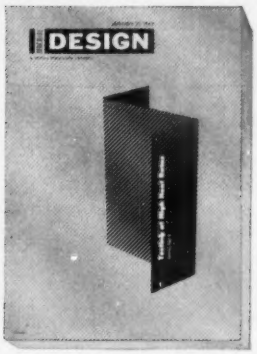
*DuPont Reg. T.M., †Reg. T.M. M. W. Kellogg Co.

Circle 405 on Page 19



Front Cover: George Farnsworth's "hot" cover design uses an optical illusion to create the effect of waves of heat striking a part. Article by John P. Moran on equipment for testing at high heat rates starts on Page 138.

January 21, 1960

Man: Low-Power Prime Mover 24

News Report—Can man be his own emergency source of power in space? Here is an up-to-date summary of research data on man's power-generating capabilities.

Wrapping Up High Pressures 26

J. J. SCAVUZZO—*News Report*—How lightweight, high-strength pressure vessels are being obtained with composite materials of plastic and metal.

Revising the Drafting Manual 118

S. W. BROSSMAN—Techniques for reorganizing the draftsman's basic reference to streamline and update its contents and to make it easier to use.

New Design Data for FEP and TFE 126

L. H. GILLESPIE, D. O. SAXTON, and F. M. CHAPMAN—*Part 1: Strength and Deformation*—General characteristics and physical properties of a new group of fluorocarbon plastics plus new and revised data for the original family of Teflon materials.

Testing at High Heat Rates 138

JOHN P. MORAN—How to design radiant-heating equipment for simulating extreme temperature rises in laboratory tests of machine structures and components.

Zero-Gradient Spring System 143

SANFORD W. GROESBERG—A simplified approach for finding the right combination of cam profile and spring proportions to provide constant tension over a given distance.

Mobility of Cross-Country Vehicles 156

M. G. BEKKER—*Part 3: Track and Wheel Evaluation*—How soil characteristics can be used in predicting the performance of off-the-road vehicles.

Geneva Mechanisms 163

MARSHALL C. SMITH—*Data Sheet*—Selection considerations and design details for a recommended "standard" series of three to nine-point Geneva drives.

CONTINUED NEXT PAGE

THE PROFESSIONAL JOURNAL FOR ENGINEERS & DESIGNERS

MACHINE DESIGN

January 21, 1960
Volume 32 — No. 2

Who Wants To Be Boss? 117
COLIN CARMICHAEL—*Editorial*

Engineering News 6

Electron-beam welder 6
Latest compacts 8
Infrared TV 10
Ultraviolet standard 12
Thermoplastic recorder 14
Turbine starter 30
X-Y Radar plotter 32
Stone-cutting flame 32
Glue-on paint 34
Commercial plasma gun ... 36
Trends 22
Meetings and Shows 36

Scanning the Field for Ideas 122

Right-angle bearings guide precision traversing member—"bouncing" light indicates liquid level—pneumatic trigger remotely controls detent mechanism—inkless recording uses carbon paper to produce continuous curve—hydraulic cushions smooth clutch action.

Design in Action 148

Tapered sleeve adjusts two tools in Swiss lathe—nerve system controls pantographic torch cutter—internal bracing adds rigidity to welded lathe bed—mechanical integrator solves simultaneous equations for fuel-injection system—motor hides in take-up spool of automatic camera.

Tips and Techniques

Perspective sketches 121
Cross-section stamp 121

Design Abstracts 171
New Parts and Materials 190
Engineering Department Equipment 236
The Engineer's Library 244
Noteworthy Patents 246
Backtalk 258
Helpful Literature 180

Subject Index 17
Reader Service Cards 19
Advertising Index 257
Business Staff 257

IN THE NEXT ISSUE: Why engineers work . . . types and characteristics of flexures . . . evaluating high-strength steels . . . optimum performance of cross-country vehicles . . . calculating critical speeds of shafts and rolls . . . cooling by evaporation

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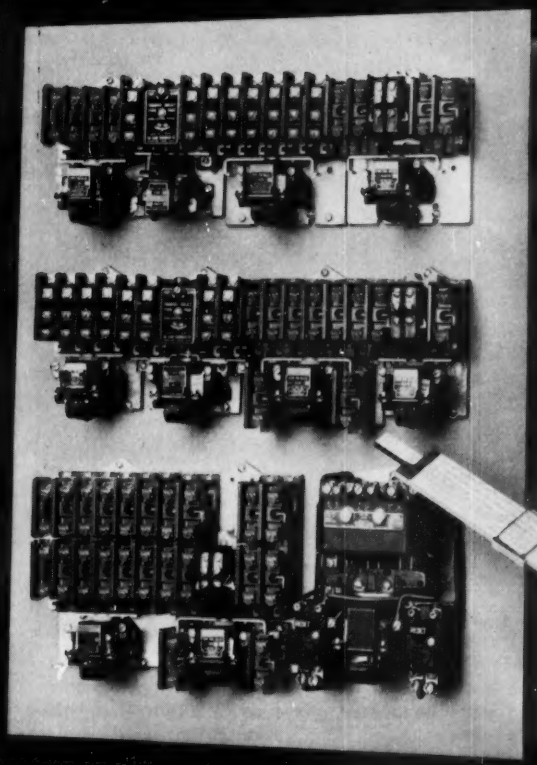
Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. When requesting changes of address, etc., please allow four to six weeks for processing.

Published every other Thursday and copyrighted 1960 by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

WHY SPACE IS
FRONT-PAGE NEWS...



Compact Clark Relays control 72 circuits from panel area smaller than a newspaper

In this day of space exploration and space economy, it's news—front page news—when you can get 72 separate, controlled circuits all on a panel no larger than 15″ x 20″.

Clark Controller, with the most complete and integrated line of control relays available today—convertible pole, latch, universal pole, and time delay—does it! And only Clark offers such a wide range of operation, so many contacts, in a panel area of such small size.

Shown mounted here with the Clark Size 1, Type "CY" Starter are 10 compact Clark Relays which include four time delay contacts (two normally open, two normally closed), 52 instantaneous contacts (14 normally open, 14 normally closed, and 24 convertible), plus 16 latching contacts (all convertible).

The same engineering leadership and superior workmanship that made Clark Controller the *standard of quality* for controls in heavy industry, is inherent in the broad line of Clark Relays for modern panels.

The "modular construction" of all Clark "PM" Relays insures integrated uniformity, compactness and flexibility. Functional alignment in mounting results in neater, more uniform panels and most efficient utilization of valuable space. And because "PM" relays are available in a wide variety of pole combinations, providing up to 14 contacts on a single relay, you can control more circuits—save on relay requirements.

For more information on the complete line of Clark "PM" Relays which is making space-saving headlines, contact your nearest Clark Controller sales office or distributor. Or, write direct to Clark Controller for free bulletins.

Circle 406 on Page 19

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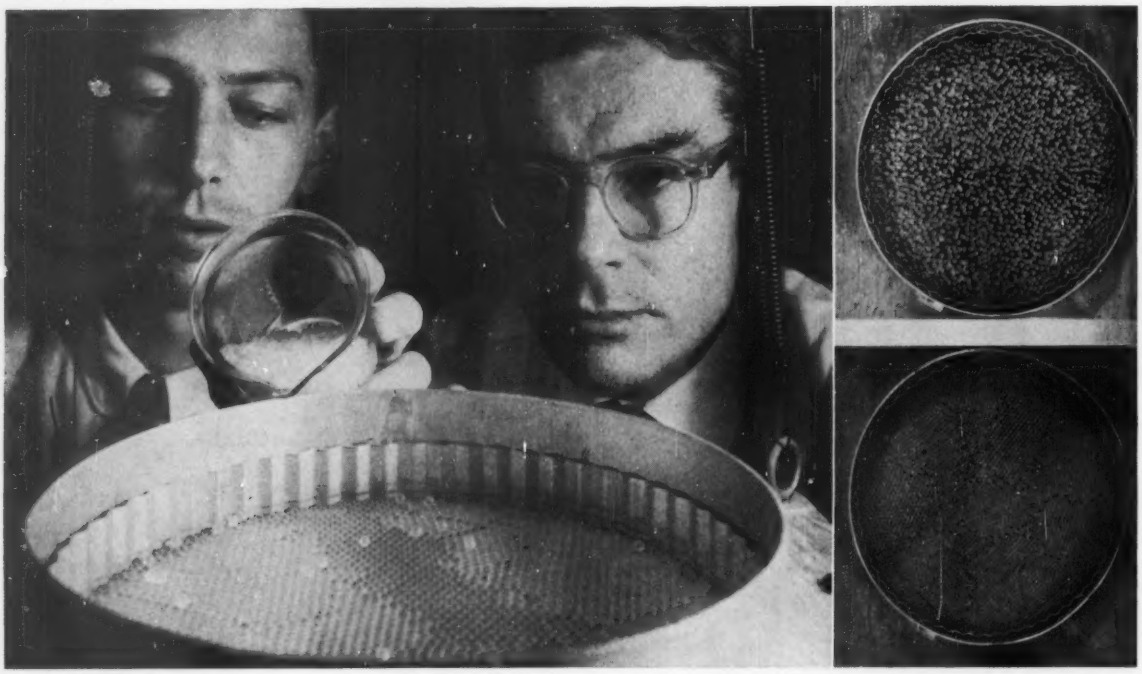
Jumping Beads Reveal Atom's Secrets



Active "atoms" visible to the naked eye may help General Electric researchers solve an important scientific problem: How atoms move in liquids. Glass beads representing atoms are poured onto a plate that is suspended from springs; atomic motion is simulated by vibrating the plate by means of a motor mounted beneath it. David Turnbull (right) and Robert Cormia, who developed the model, point out that vibration keeps the beads in the ceaseless random motion that atoms are believed to be in at all times. The model thus illustrates "a remarkable number of atomic interactions that are believed to occur in actual matter." Bead configurations can be photographed for later study. A few beads on the moving plate behave as atoms do in a gas—they move rapidly over relatively long distances between collisions with other atoms and do not arrange themselves in a particular pattern. Addition of more beads to represent a liquid (right, above) shortens the distances traveled by the atoms, but they still move rapidly and show no pattern. When the simulated matter reaches a solid state, atomic structure shows grain boundaries (right, below).

U. S. To Get German Electron-Beam Process

It's More Versatile Than Ours, According to United Aircraft

WINDSOR LOCKS, CONN.—Wide acceptance of electron-beam machining as an efficient tool for handling the hardest known materials has led to the importation of a powerful new process from Germany. United Aircraft's Hamilton Standard Div. will build equipment utilizing the process under an agreement with the Carl Zeiss Foundation.

The Zeiss process appears to be extremely versatile. Incorporated in a welding machine, for example, it easily handles stainless steel for aircraft and missile structures, producing "T" sections 0.06-in. thick from sheet stock at a rate of 2 ft per min. It will butt-weld $\frac{3}{8}$-in. stainless steel at 0.33 in. per sec and has, in the laboratory, welded through 1-in. stainless-steel plate. It does this without distortion of the piece and with minimum grain growth in the weld area; the first because of the narrowness of the heat affected area (depth-width ratios as high as 20 to 1), the second because of extremely rapid heating and cooling (i.e., low total energy input to work piece). Flexibility of the machine, and the precise focusing of the electron beam, permit welding of complex shapes in hard-to-weld metals. A major improvement in the welding of reactor cores for atomic energy installations has been one of its notable applications.

Electronics manufacturing appears to be a particularly promising area for the Zeiss process because of the accelerated develop-

Salt River Valley Water Users Association,
Phoenix, Arizona

Saves $699.00 per pump...

by using ground and polished

fatigue-proof® STEEL BARS **e.t.d.®**

made by elevated temperature drawing process

The men who operate the "Salt River" project have the job of supplying water to 240,000 acres of land in Arizona, where the Gila River joins the Salt River. The Association maintains some 250 deep well pumps to help supply the required water.

Richard Juetten, Supervisor of Salt River's Pump Division, reports that the use of La Salle FATIGUE-PROOF steel bars has permitted a saving of $699.00 per pump . . . a potential saving of $174,750 when applied to the 250 pumps now in operation.

Mr. Juetten's report follows:

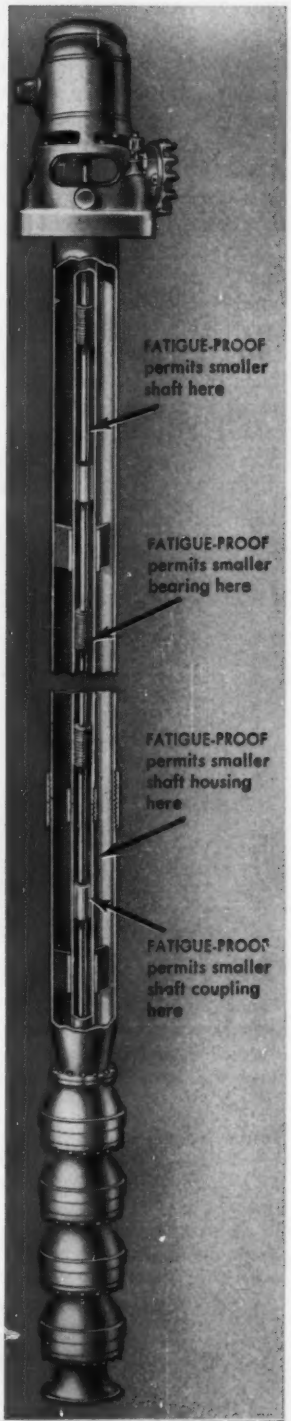
"I have figured our direct saving realized by using La Salle FATIGUE-PROOF steel bars in place of standard C-1045 steel shaft in our deep well turbine pumps.

"FATIGUE-PROOF enables us to use bars only $1\frac{11}{16}$" in diameter . . . instead of $2\frac{3}{16}$" diameter shafts which were necessary when we used C-1045 . . . and this despite higher horsepower, more weight, and additional pump bowl assemblies.

"Here are comparative costs per 10-foot section (of a 300-foot pump shaft):"

using C-1045		using FATIGUE-PROOF	
10′ x 2-3/16″ dia. shaft	$28.30	10′ x 1-11/16″ dia. FATIGUE-PROOF	$22.59
3½″ shaft housing	26.30	3″ shaft housing	19.80
2 bearings, 3½″ x 2-3/16″	21.72	2 bearings, 3″ x 1-11/16″	13.46
Shaft coupling	5.16	Shaft coupling	2.34
TOTAL cost	$81.48	TOTAL cost	$58.19
Cost per foot	$ 8.15	Cost per foot reduced to	$ 5.82

RESULT: A saving of $2.33 per foot . . . or $699.00 when applied to a 300-foot pump setting. And this doesn't take into consideration reduced power consumption.


FATIGUE-PROOF permits smaller shaft here
FATIGUE-PROOF permits smaller bearing here
FATIGUE-PROOF permits smaller shaft housing here
FATIGUE-PROOF permits smaller shaft coupling here

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Circle 407 on Page 19

ment in componentry miniaturization. Many new electronic components require working with tool diameters so small that mechanical processing is practically impossible.

When used for machining, the Zeiss process will "create" holes and slots with a cross section of only 0.0008 in. in the hardest materials. Energy density during drilling sometimes reaches 600 million watts per square inch. Increased energy and density and the ability to produce much smaller holes and slots are expected in the near future.

Most of the energy used in machining is dissipated as vaporization of the material, rather than into thermal heat, resulting in extremely low relative temperatures around the machined area. For example, with an 11,000 F temperature at the target point, a temperature of only 550 F is registered one micron away from the edge of the cut.

The process can be controlled by electrical relays, or by complete electrical and mechanical automation. In the Zeiss laboratory, paper tape, magnetic tape and television controls have been used successfully. One system now in use handles 10,000 jewel watch bearings in a load, drilling each one in about 6 seconds and showing the remarkably high beam efficiency of about 90 per cent. Similar production is reportedly possible with any product that lends itself to automation.

Two More Compacts

Corvair coupe, a two-door, five-passenger version of Chevrolet's compact, is distinguishable from its four-door predecessor by a "faster roof line and larger rear-wheel openings which give it a sports-car appearance." Coupe and sedan have the same basic dimensions and share equipment and accessory options.

Falcon wagon, in two and four-door versions, will begin pouring off Ford assembly lines in mid-February. Designed to seat six in comfort, the wagon is 189 in. long, or 8 in. longer than Falcon two- and four-door sedans. Cargo volume is almost 76 cu ft, nearly equal that of the standard '57 Ford wagon. In addition to single-unit construction and bolt-on front fenders, Falcon boasts the lowest tailgate floor-loading height in the industry (2 ft) and the biggest brake-lining-area-to-vehicle-weight ratio of any station wagon.

Topics

Spoilsports in the boroughs of Brooklyn and Queens, New York, are substituting butyrate plastic fire globes for glass ones. Mounted on street light poles next to fire alarm boxes to mark locations of the boxes, the orange globes seem to be irresistible targets and—when made of glass—very vulnerable ones too. Replacement rate for breakage so far has been cut by 50 to 75 per cent, and this percentage will rise as the whole system becomes converted to plastic globes within a year.

• • •

Less noise in suburban neighborhoods is promised by two prize-winning developments. Certificates of award for contributing to the cause of noise abatement were made by the National Noise Abatement Council recently to the Lawn-Boy Div., Outboard Marine Corp., for its quieter lawn mower motor and assembly and to the Silent Knight Co. for a quiet manhole cover.

• • •

Shrinking electronic equipment that goes into aircraft causes a marked expansion in the laboratory equipment used to check its accuracy and reliability. An example is the airborne telemetering system used in the Navy's Subroc antisubmarine weapon system, for which Goodyear Aircraft Corp. is the primary contractor. The telemetering system and its support equipment occupy a package approximately 10 in. in diameter and 24 in. long; it weighs about 75 lb. Checking out the system requires nine racks of electronic equipment, and each rack is at least 6 ft high and occupies a cubic volume some 238 times greater than the equipment under test.

• • •

The big picture in television for 1960 is a bigger picture, according to the Admiral Corp., which expects to have 75 per cent of this year's sales of TV sets in models with a new wide-angle, 23-in. picture tube.

• • •

First aid with foam Latex is given casualties of Air Force rocket-sled tests. Victims are 6-ft, 200-lb robots made with steel and aluminum bones and joints and vinyl-dipped foam Latex by Sierra Engineering Co., Sierra Madre, Calif. Common complaints are torn-off heads, broken backs and limbs, and slashed, smashed, burned, or bent bodies, even though the robots are built to take 100 g. They are shaped and weighted like men and have man's center of gravity; some can bleed, breathe, feel heat and cold, and sense shock in a manner that parallels a human's feeling of pain.

4 metal part assembly for → Rockwell Manufacturing Company Automatic Voting Machine Division JAMESTOWN, NEW YORK

Becomes a Single Part in Molded Nylon by-Quinn Berry

An almost fantastic challenge! . . . Quinn-Berry engineers and craftsmen replaced the 4 piece brass, phosphor bronze and strip steel assembly of the actuator in the Automatic Voting Machine by a single molded nylon part . . . the manufacturer effected an equally fantastic saving.

Note in the above illustration how the single molded nylon part, shown in actual size, eliminated a tedious and delicate assembly job on the manufacturer's production line. Molded to the most exacting tolerances, this nylon actuator is self lubricating, quiet and completely accurate in operation, a vital requisite in Automatic Voting Machine operation.

Such challenges are being met daily at Quinn-Berry where the Unusual is Routine. Consult with us on the use of molded thermoplastics . . . you too may be able to effect amazing cost savings.

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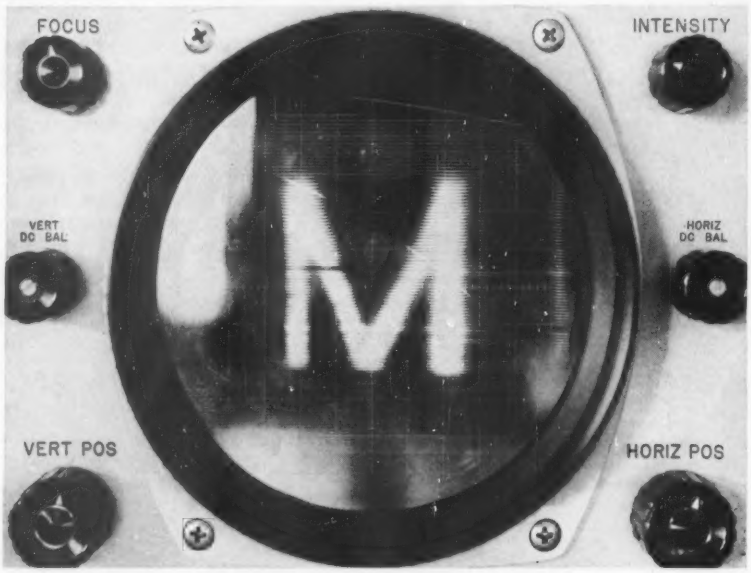
Circle 408 on Page 19

Infrared Image Pictured on "TV"



Electronically reproduced images of heat sources now boast good picture quality. The television-type image is formed in a 150 line per in. pattern, but TV scanning rates (525 lines per in.) could also be used if particular applications called for higher definition. Developed by Philco Corp., Philadelphia, electronic scanning is some 30 times faster than mechanical systems that use moving mirrors to scan at one frame per second. The new system allows close monitoring of changes in direction of motion and heat intensity of a target. The test M pictured was generated by a 250-F surface.

Best Traits of Solids, Liquids Merged in Hybrid Rocket Engine

DENVILLE, N. J.—Among the many frustrations that plague missile designers, one of the biggest involves solid vs. liquid propellants: The best oxidizers in the business are liquid, the best fuels are solid. The logical solution would be to combine the two . . . a feat that Thiokol Chemical Corp. is trying to perform for the Air Force.

In a carefully worded statement, Thiokol engineers have just made known some impressive "preliminary" results. A "hybrid" engine now on the test block, can be shut down, restarted, and throttled over its full thrust range. Since the hybrid benefits from a gain in bulk density (over liquid bi-propellants) without the loss in specific impulse associated with solid fuels, it shows more promise of achieving specific impulse values in excess of 300 sec than any noncryogenic system.

These tests were probably the basis for Thiokol's prediction, made several weeks ago, that a 10-million-lb solid booster could be ready for space work as soon as, or sooner, than comparable liquid boosters.

Style Note: Swept Fin Shows Up on Airplanes

Styling, long the watchword of the automobile industry, may be gaining a foothold among aircraft manufacturers. Cessna Aircraft's new 1960-version of the 310 features "complete redesign of the vertical fin and improvements in comfort and convenience." Nonstyling changes include a new noncongealing oil cooler and a quick-drain valve added to auxiliary tanks to provide a convenient means of draining water or sediment. According to Cessna officials, extensive styling changes inside and out the 310D were highlighted by sweeping back the vertical fin 40 degrees, which gives the airplane a long, low look. Interiors are richly styled with luxurious new fabrics, leather, and frosty walnut trim. Company executives say the new twin-engine plane with its many changes should increase in popularity in the 1960 market. Despite increased costs of labor and materials, price will remain about $60,000.

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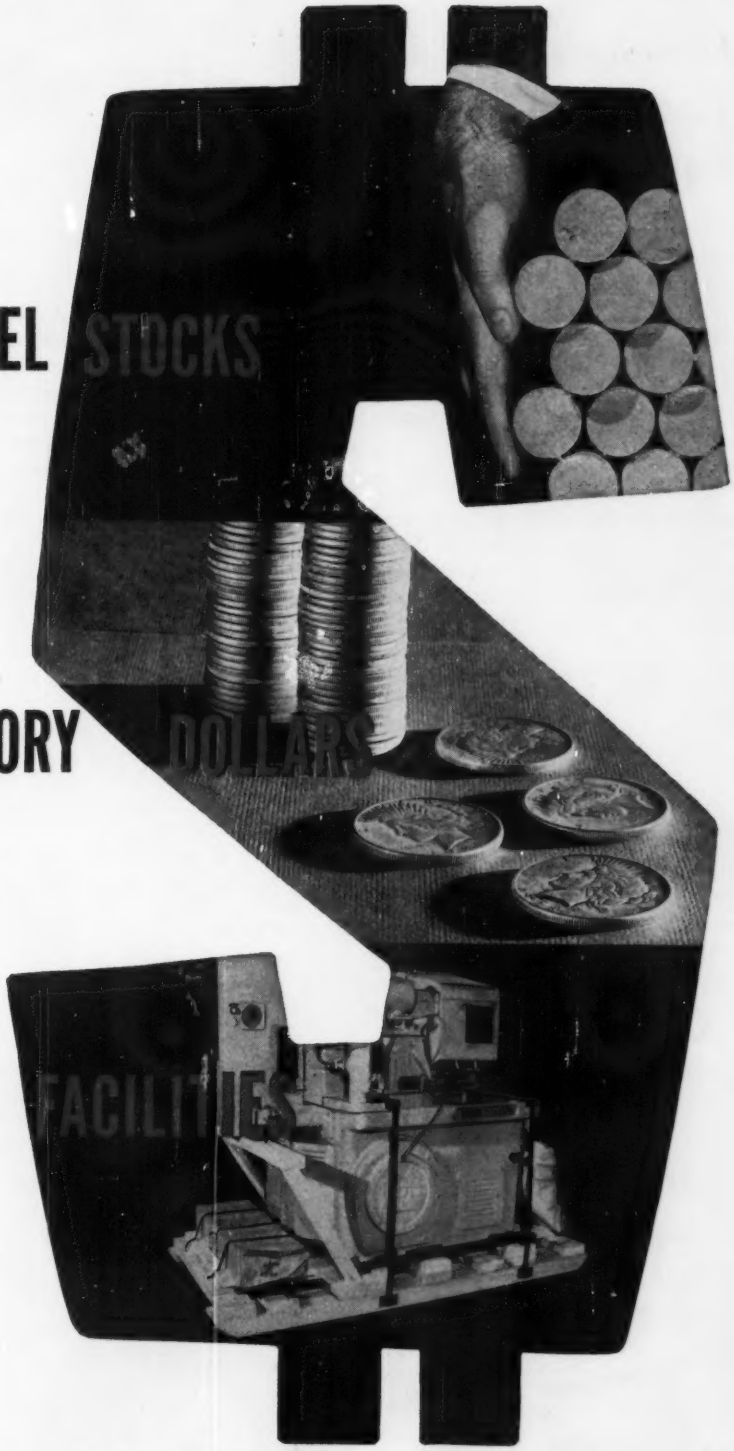

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The Black Body: Classroom Concept Becomes Ultraviolet Standard

WASHINGTON — Radiant - energy measurement in the near-ultraviolet range may soon be greatly simplified. National Bureau of Standards' scientists have come up with a new primary standard that allows accurate and direct calibration of secondary standards used by industry.

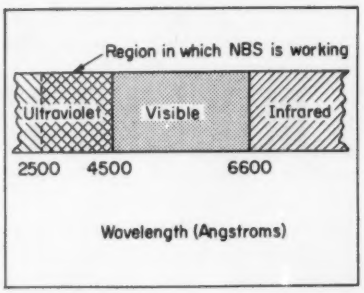
In the past, the Bureau's standard in the near ultraviolet has been a tungsten-ribbon lamp. But this lamp has drawbacks: Radiation from the tungsten ribbon can not be determined by absolute measurement of spectral emission; it must be calculated from temperature measurements and emissivity of the ribbon.

A more suitable standard would be the physicist's "ideal" radiator, the black body. Such a radiator would:

- Emit the maximum radiation possible at a given temperature.
- Emit radiation that is independent of radiator material.
- Allow accurate calculation of radiation as a function of temperature and wavelength.

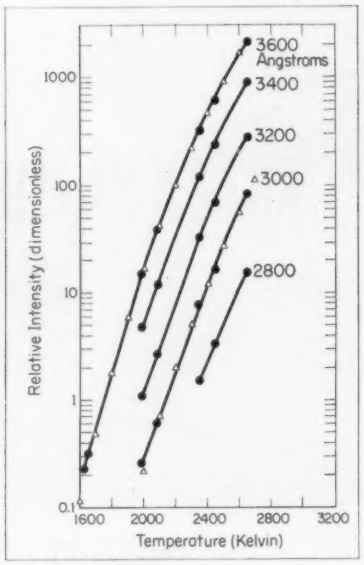
By applying a number of developments in other fields, the Bureau's R. Stair and R. G. Johnston have developed a black body to replace the tungsten-ribbon emitter. The radiator had to await recent studies on high-temperature behavior of materials (including insulating materials) and techniques for producing high-purity graphite. Another development that made it possible was the shielded radio-frequency generator which produces negligible interference in photoelectric amplifier systems.

Radiation with black-body temperatures ranging from 2000 to 2600 K (approximately 4100—5200 F) was compared to results calculated from Planck's law, and the two values were found to closely agree. The high temperatures generated measurable wavelengths as short as 2500 angstroms, well beyond the short-wave limit of the visible spectrum (about 3500 angstroms). The black body is now being used to set up working-lamp standards from the near-ultraviolet to the near-infrared regions, i.e., from 2500 to 7500 angstroms. A group of strip lamps are also being calibrated for this wavelength range.



Near-ultraviolet part of the electromagnetic spectrum was of prime interest. No black body for this region could be developed until high-temperature technology could supply materials able to withstand and insulate against temperatures as high as 5000 F. With the newly developed radiator, the National Bureau of Standards can use one primary standard for calibrating from the near ultraviolet to the near infrared.

High-purity graphite cylinder, 1.5 in. diam, 4.5 in. long, 3/16 in. thick, forms the black-body radiator. The cylinder is insulated with boron nitride powder, poured between it and a porcelain container (left). An induction coil operated by a high-frequency generator (right) heats the black body in an inert atmosphere which prevents the graphite from oxidizing at high temperatures.



Radiant-energy intensities were determined at selected wavelengths and black-body temperatures. Experimental data (shown as circles) agreed well with calculated data (shown as triangles). The black body is now being used to calibrate secondary ultraviolet standards for industry.

Torrington Needle Bearings are available for shafts up to 7¼" in diameter. Full complement of rollers provides highest radial capacity for a given cross section. They offer low unit cost, compactness and light weight and long service life. They take a press fit in a simple straight-bore housing, run directly on hardened shafts, permitting use of larger and stiffer shafts.

Why not put a Torrington Needle Bearing on that large shaft?

You have everything to gain by applying a large diameter Torrington Needle Bearing in your heavy duty applications.

There's the unusual economy in price and installation cost over other anti-friction bearings of comparable size. Simplicity of design of related components saves even more. Unequaled capacity for a given cross section, good lubrication and efficient anti-friction operation mean long service life.

These advantages have been proved in performance in tractor bolsters, transmissions and final drives. In haybaler crank shafts. In power shovels. In heavy duty hydraulic pumps and starting motors. In road wheel arms on tanks. Why not talk over *your* application with your Torrington representative? **The Torrington Company, Torrington, Conn.—and South Bend 21, Ind.**

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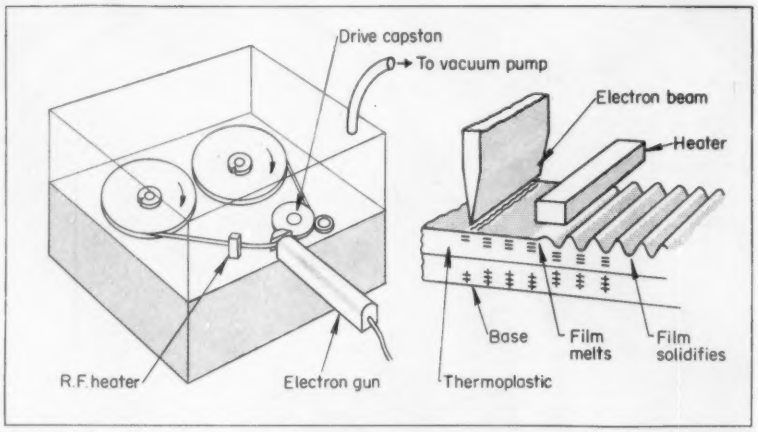
Circle 410 on Page 19

Rippled Surface Stores Data In New Thermoplastic Tape Recorder

Electron Charge, Surface Tension Set Up Readable Ridges

SCHENECTADY, N. Y.—New competition for magnetic tapes is expected from thermoplastic recording, a development fresh out of General Electric's research labs. The system boasts many of the advantages of other recording methods and adds some new ones of its own. Like magnetic tapes, thermoplastic tapes are easily erased, can be played back without going through a developing stage, and put out high-quality signals. However, they're reportedly easier to duplicate than magnetic tapes, and easier to edit.

The most obvious applications for the new system are in TV-picture recording and movie making, according to GE spokesmen. In these jobs, ease of duplication is very important. Possibly, prerecorded sound or TV tapes could be rented or sold to the public for playback, but home recording systems are still in the future. Such systems would be too delicate to be practical, at least at the machine's current state of development.



Thermoplastic-tape recorders look something like magnetic-tape recorders, but there the similarity stops. The tape's film is charged by the electron beam, heated by the rf heater, and finally allowed to cool. The information-carrying ridges form in a matter of milliseconds once the film melts, and the entire heating time takes only about 0.01 sec. During the record process, the continuously pumped vacuum chamber keeps air molecules from between the electron gun and the tape. If air molecules disperse the electron beam only low quality information is transferred to the tape. The tape is actually made up of three sections (although only two sections are shown, right). The film contains the recorded information and the base acts as a carrier. The two are separated by an electrically conducting coating which is the target for the rf heating energy; in it, current is induced to melt the film once the electron charge is deposited.

How It Records:

The recorder, developed by Dr. W. E. Glenn, uses an electron beam and radio-frequency heating to store information in a thermoplastic film on a carrier tape. Information to be recorded is first converted into electrical signals. The signals, impressed on a specially designed electron gun, control the intensity of the gun's beam. As the tape moves "under the gun," the beam lays an electron density that is characteristic of the control signal. The charge is entirely captured by the thermoplastic film.

Once the tape has moved beyond the beam, the rf heater melts the film. Electrostatic forces between the film's electrons and the ground plane, i.e., positive charges in the carrier tape, pull the film down until they are balanced by surface-tension forces. At this time, surface deformations—ridges and valleys—have formed and the film is allowed to cool. The ridges and valleys are the signal-storing mechanism on the tape.

To keep air molecules from dispersing the electron beam, the recording process is carried out in a vacuum.

How It Reads and Plays Back:

Recorded signals are reproduced optically. The ridges on the tape form a diffraction grating for a beam of light transmitted through the film, and special optical systems have been worked out for reproducing both black-and-white and full-color images on a screen. About four times more information—hence, four times the film area—is necessary to reproduce a color picture than is required for black-and-white.

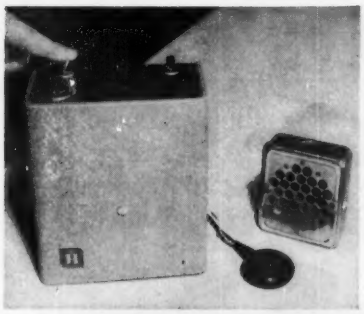
If the recorded signal is to be reproduced in other than picture form, e.g., sound, analog or digital data, a TV-like system can be used to scan the screen and convert the "picture" into usable electrical signals.

Erasing is accomplished by heating the film to a higher temperature than the recording melt temperature. Surface-tension forces smooth out the deformations (surface tension becomes much greater than the electrostatic forces) and the film is ready for reuse. Pinpoint erasures are possible with a spot-heating technique.

Competition for Videotape:

Unique advantage of the thermoplastic recording system is ease of making duplicate tapes. Copies can be stamped from a master in a process similar to the pressing of phonograph records. Magnetic tapes are reproduced by recording duplicates from a master tape.

First application of the new recorder will probably be in the field of television tape recording. Other advantages over videotape recorders now in use include smaller size and capacity for more information on the same amount of tape. In addition, GE spokesmen indicate the thermoplastic recorders may be considerably less expensive.



This Lifeguard Can't Swim

A slight hand splash in the swimming pool will set off a call for help from this pool-side observer. It's similar, in operation, to submarine-detection equipment. The sensing element (disc in center) is encased in a protective box (right) and mounted on the pool wall 12 in. below water level. When an object falls into the unattended pool, the sensing element detects the sound vibration and relays an activating signal to the alarm panel (left). Developed by Minneapolis-Honeywell, the lifeguard costs about $200.

Prolific Plastics Gain in '59; Promise More Growth This Year

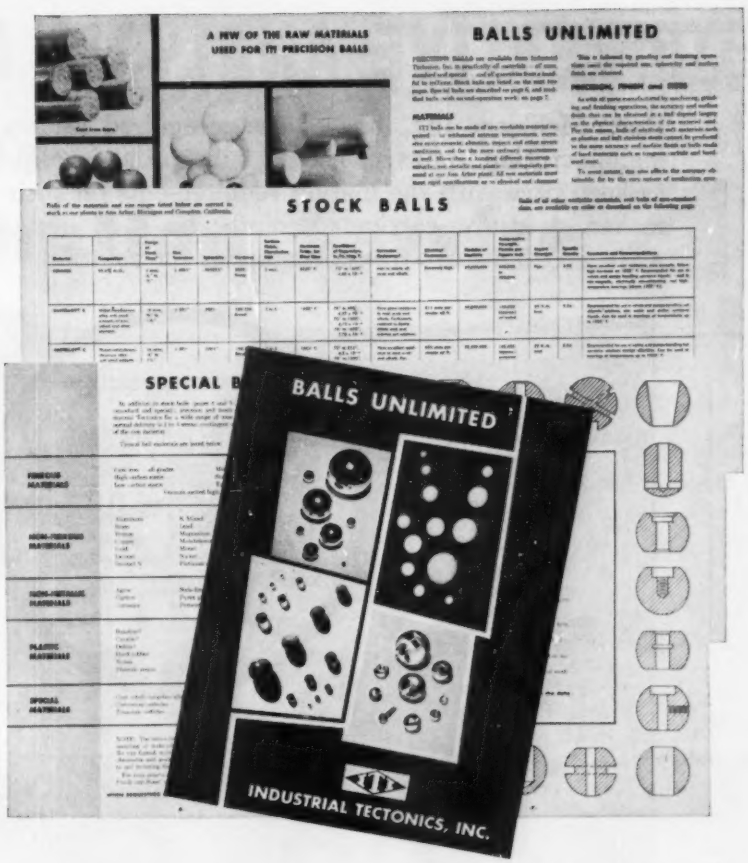
NEW YORK—More than 5½ billion pounds of plastics were produced last year, a 25 per cent increase over 1958, according to an estimate of the Society of the Plastics Industry Inc. Furthermore, the industry aspires to increase its volume an additional 25 per cent in 1960; however, SPI foresees a 15 per cent increase as more realistic, since such ambitious expansion takes time.

One area of the plastics industry, mold making, declined during the first months of 1959, but it made a comeback in June and increased each month thereafter. This trend points to new business and many new plastics products.

Estimated 1959 production (in pounds) of some of the basic plastic raw materals is:

Cellulosics	158,000,000
Phenolics	610,000,000
Polyesters	150,000,000
Polyethylene	1,200,000,000
Polystyrene	910,000,000
Urea and Melamine	400,000,000
Vinyls	1,100,000,000

These figures include a first in the plastics industry: The one-billion-pound mark was passed—by both polyethylene and vinyl.



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Circle 411 on Page 19

CREATIVE ANALYSIS PAYS OFF!

Rudd-Melikian, Inc., one of the recognized leaders in the vending machine manufacturing industry, needed substantial increases in production efficiency to keep pace with the market requirements on their new "Brew-a-cup" coffee maker. A study, conducted jointly by R-M and AMP engineers, indicated AMP-lok multiple wire connectors as the solution.

ADVANTAGES: AMP-lok snap-assembly connectors . . .

- replace bulky solder-type connectors
- permit use of modular construction techniques
- facilitate final assembly and in-service maintenance

THE "PAY-OFF": Twice the previous production volume of electrical control harnesses with no increase in production facilities.

You can start your creative analysis to better wiring with a request for AMP-lok information, today.

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SUBJECT INDEX

Editorial and Advertising content classified by subject and listed by page number for convenience when studying specific design problems. For further information on subjects advertised, refer to advertisement and circle Item Number on a Yellow Card—following page.

Adhesives, Adv. 233, 234
Airplanes, Edit. 10
Alloys, high temperature, Adv. 47
Atomic research, Edit. 6
Automobiles, compact, Edit. 8

Balls, Adv. 15
Bars, rods, and rolls, Adv. 192
Bearings,
  ball, Adv. 21, 53, 72, 108, 237, 243
  miniature, Adv. 185, 190, 212
  needle, Adv. 13, 238
  roller, Edit. 122; Adv. 72, 84, 92, 207, 243, back cover
  sleeve, Adv. inside front cover, 77
  thrust, Adv. 92
Belts, transmission, Adv. 36, 48, 99
Blowers, Adv. 54
Books, Edit. 244
Brakes, Adv. 113, 201, 215, 249
Brazing alloys, Adv. 222

Cameras, motor-driven, Edit. 155
Capacitors, Adv. 194
Caps, Adv. 225, 256
Carbides, cemented, Adv. 65
Carbon and graphite parts, Adv. 44
Casters, Adv. 247
Castings,
  die, Adv. 116, 253
  investment, Adv. 217
  iron, Adv. 229
  meehanite, Adv. 235
  nonferrous, Adv. 256
  steel, Adv. 186
Chain, transmission, Adv. 29, 43, 106
Clamps, Adv. 249
Clutches, Edit. 125; Adv. 201, 215, 241, 244
Coatings (see also Finishes),
  protective, Adv. 50, 206
Cold heading, Adv. 242
Compressors, Adv. 255
Computers, Edit. 32
Connectors, electric, Adv. 16, 214
Control systems, Adv. 90
  mechanical, Adv. 248
Controls,
  electric, Adv. 46, 87, 103
  pneumatic, Adv. 87
Converters, Adv. 246
Couplings,
  fluid flow, Adv. 230, 254
  shaft, Adv. 36, 196, 223, 230, 251
Crystals, refractory, Edit. 22
Cutting machine, tracer, Edit. 150
Cylinders,
  hydraulic, Adv. 61, 216, 221, 250, 253
  pneumatic, Adv. 61, 178, 221, 250, 255

Detent mechanisms, Edit. 124
Diaphragms, Adv. 35, 234
Dowel pins, Adv. 204
Drafting equipment, Adv. 63, 91, 173, 174, 194, 198, 239, 242, 250
Drafting manual revision, Edit. 118
Drafting techniques, Edit. 121
Drives, adjustable speed, Adv. 36, 56, 93, 192, 197, 218, 244, 249

Electric equipment (see specific type)
Electronic equipment, Edit. 6, 8, 10, 14; Adv. 43, 50, 198, 209, 218, 220, 239, 242
Engineering department (see Management or Drafting)

Fans, Adv. 54, 69, 189, 192
Fasteners,
  bolts, studs, screws, Adv. 52, 80, 88, 196, 252, 254, inside back cover
  nuts, Adv. 190, 193, 246, 252
  pin, Adv. 109
  retaining rings, Adv. 195
Feeders, parts, Adv. 203
Fiber, Adv. 40, 66
Filters, Adv. 226, 251
Finishes (see also Coatings), protective, Edit. 34
Fittings, pipe, tube, and hose, Adv. 79, 177, 223
Fluid couplings, Adv. 96
Forgings, Adv. 183
Forming, Adv. 100

Gages (see also Instruments), pressure, Adv. 64, 245
Gaskets, Adv. 68
Gear boxes, Adv. 216
Gears, Adv. 43, 75, 181, 220, 234
Geneva mechanisms, design of, Edit. 163
Glass, Adv. 179
Ground ways, Adv. 200

Handles, Adv. 251
Heaters, Edit. 138; Adv. 42, 174, 179, 198
Honeycomb materials, Adv. 260
Hydraulic equipment (see specific type)

Instruments,
  components, Adv. 253
  liquid-level indicator, Edit. 123
Insulators, Adv. 198
Integrator, mechanical, Edit. 154

Lathe, miniature automatic, Edit. 148
Lighting, Adv. 206
Lubrication
  equipment, Adv. 111
  systems, Adv. 1

Measurement, precision, Edit. 12, 22
Meetings, Edit. 36
Metals (see specific type)
Motors, (electric), Adv. 112
  fractional and integral hp, Adv. 76
  gearmotors, Adv. 70
  subfractional hp, Adv. 192
  synchronous, Adv. 224
Motors, Adv. 81
  pneumatic, Adv. 102
Mountings, vibration and shock, Adv. 60, 246

Nickel and alloys, Adv. 55

MACHINE DESIGN is indexed in Industrial Arts and Engineering Index Service, both available in libraries, generally

Oscillograph recorders, Adv. 240

Plastics, Edit. 8, 15, 126; Adv. 40, 58, 82
  laminates, Adv. 40, 73, 200, 232
  metal composites, Edit. 26
  molding, Adv. 9, 31, 49, 73
Plugs, Adv. 194, 225, 256
Pneumatic equipment (see specific type)
Potentiometers, Adv. 218
Powder metallurgy, Adv. 210
Prime mover, human, Edit. 24
Pulleys (see Sheaves)
Pumps,
  hydraulic, Adv. 69, 176, 196, 211, 213, 218, 234, 248
  pneumatic, Adv. 248
Pushbuttons, Adv. 89, 103

Recorders, inkless, Edit. 124, 236
Rectifiers, Adv. 224
Reducers, speed, Adv. 83, 203, 210
Relays, Adv. 5, 110, 200, 227, 229
Rheostats, Adv. 74
Rotary joints, Adv. 255

Screws, power, Adv. 105
Seals, Adv. 2, 188, 190, 204, 206, 209, 228, 232, 239
  mechanical, Adv. 202, 239
Shafts, flexible, Adv. 208
Sheaves, Adv. 37, 48, 218
Sheet-metal parts, Adv. 247
Shims, Adv. 107
Springs, Edit. 23; Adv. 184
Spring system, zero-gradient, Edit. 143
Starters, motor, Edit. 30
Steel, Adv. 7, 11, 78, 94
  stainless, Adv. 33, 86
Switches, Adv. 97, 110, 192, 214, 220, 223, 227, 236
Systems, pneumatic, Edit. 171; Adv. 214

Tape, Adv. 213, 216
Terminals, Adv. 206, 229, 247, 250
Testing, at high heat rates, Edit. 138
Textured metals, Adv. 240
Thermocouples, Adv. 236
Thermostats, Adv. 231
Torches, high temperature, Edit 32, 36
Tubing, Adv. 114, 170, 194, 210

Universal joints, Adv. 191, 219, 242

Valves,
  hydraulic, Adv. 27, 90, 196, 203, 209, 224, 256
  pneumatic, Adv. 187, 190, 205, 224, 230, 252, 255
Vehicles, mobility of, Edit. 156

Weldments, lathe bed, Edit. 153
Wire and wire products, Edit. 23; Adv. 38, 104, 115

USE A YELLOW CARD *for More Information . . .*

CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

Index to New Parts & Helpful Literature
BY ITEM NUMBERS

HELPFUL LITERATURE—descriptions start on page 180

	ITEM NUMBER
Electronic Voltmeters	641
Snap-Action Switches	642
Remote-Control System	643
Silicone Rubber	644
Wire Products	645
Aerospace Fasteners	646
Printed-Circuit Tapes	647
Pressure Cutoff	648
Reinforced Polyester	649
Hydraulic Fitting	650
Speed Recorders	651
Miniature Power Pack	652
Steel Collars	653
Cold-Finished Shapes	654
Typed Symbols	655
Heat-Exchanger Tubes	656
Wiring System	657
Specialty Metals	658
Silicone Rubber	659
Digital Data Recorder	660
Railway-Car Batteries	661
Precision Switches	662
Filter Elements	663
Permanent Magnets	664
Flow Proportioner	665
Small Inductors	666
Postforming Plastics	667
High-Temperature Alloy	668
Wind Tunnel Testing	669
Lapping-Polishing Machines	670
Hydraulic Check Valves	671
Centrifugal Pumps	672
Copper-Plated Wire	673
Sensing Control	674
Tape Recorders	675
Electronic Chronograph	676
Suspension Scale	677
Boiler-Water Gages	678
Motor Protectors	679
Geared-Belt Drives	680
Sealless Pumps	681
Formula Control	682
Fasteners	683
Diesel & Carbureted Engines	684
Recording Oscillograph	685
Germanium Diodes	686
Flow Meter	687
Molded Packings	688
Servo Valves	689
Single Choppers	690
Insulating Varnishes	691
Leakproofing Nuts	692
Pressure Leak Detector	693
Door-Interlock Switch	694
High-Strength Bolts	695
Servo System	696
Strain Gage	697
Medium-Power Transistors	698

NEW PARTS & ENGINEERING EQUIPMENT—descriptions start on page 190

	ITEM NUMBER
Instrument Bearings	699
Bracket Nut	700
Miniature Valve	701
Asbestos Gasket	702
Subminiature Switch	703
Adjustable-Speed Drives	704
Nylon Pressure Tubing	705
Tantalum Capacitor	706
Directional-Control Valve	707
Flexible Coupling	708
Epoxy Insulating Compound	709
Time-Delay Devices	710
Program Relay	711
Laminated Plastics	712
Needle Valves	713
Speed Reducers	714
Shaft Seal	715
Pilot Light	716
Clips and Terminals	717
Silicone Varnish	718
Plastic Gate Valve	719
Silicone Mesa Diodes	720
Tubing Insert	721
Servo-Motor Gearheads	722
Teflon-Film Tape	723
Positive Displacement Pump	724
Connecting Devices	725
Footswitches	726
Electrical Tape	727
Bevel-Gear Boxes	728
Ten-Turn Potentiometer	729
Centrifugal Pumps	730
Pendant Switch	731
Transistor Pad	732
Fittings and Flanges	733
Pressure Switches	734
Solenoid Valve	735
Cathode-Type Rectifier	736
Printed-Circuit Relays	737
Unit Switches	738
Telephone-Type Relay	739
Hermetic Terminals	740
Solenoid Valve	741
Flexible Connectors	742
Printed-Circuit Laminate	743
Leakproof Pump	744
General-Purpose Adhesive	745
Diaphragm	746
Thermal Ribbons	747
Portable Recorder	748
Roll Files	749
Magnetic-Tape Transport	750
Transformer Amplifier	751
Punched-Tape Reader	752
Double Eraser	753

MACHINE DESIGN
Jan. 21, 1960

Circle item number for information on products advertised or described or copies of literature.

401	431	461	491	521	551	581	611	641	671	701	731	761	791	821	851
402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
422	452	482	512	542	572	602	632	662	692	722	752	782	812	842	872
423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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Page No.	Title of Article
.....	.....
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402	432	462	492	522	552	582	612	642	672	702	732	762	792	822	852
403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
411	441	471	501	531	561	591	621	651	681	711	741	771	801	831	861
412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
421	451	481	511	541	571	601	631	661	691	721	751	781	811	841	871
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423	453	483	513	543	573	603	633	663	693	723	753	783	813	843	873
424	454	484	514	544	574	604	634	664	694	724	754	784	814	844	874
425	455	485	515	545	575	605	635	665	695	725	755	785	815	845	875
426	456	486	516	546	576	606	636	666	696	726	756	786	816	846	876
427	457	487	517	547	577	607	637	667	697	727	757	787	817	847	877
428	458	488	518	548	578	608	638	668	698	728	758	788	818	848	878
429	459	489	519	549	579	609	639	669	699	729	759	789	819	849	879
430	460	490	520	550	580	610	640	670	700	730	760	790	820	850	880

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403	433	463	493	523	553	583	613	643	673	703	733	763	793	823	853
404	434	464	494	524	554	584	614	644	674	704	734	764	794	824	854
405	435	465	495	525	555	585	615	645	675	705	735	765	795	825	855
406	436	466	496	526	556	586	616	646	676	706	736	766	796	826	856
407	437	467	497	527	557	587	617	647	677	707	737	767	797	827	857
408	438	468	498	528	558	588	618	648	678	708	738	768	798	828	858
409	439	469	499	529	559	589	619	649	679	709	739	769	799	829	859
410	440	470	500	530	560	590	620	650	680	710	740	770	800	830	860
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412	442	472	502	532	562	592	622	652	682	712	742	772	802	832	862
413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
414	444	474	504	534	564	594	624	654	684	714	744	774	804	834	864
415	445	475	505	535	565	595	625	655	685	715	745	775	805	835	865
416	446	476	506	536	566	596	626	656	686	716	746	776	806	836	866
417	447	477	507	537	567	597	627	657	687	717	747	777	807	837	867
418	448	478	508	538	568	598	628	658	688	718	748	778	808	838	868
419	449	479	509	539	569	599	629	659	689	719	749	779	809	839	869
420	450	480	510	540	570	600	630	660	690	720	750	780	810	840	870
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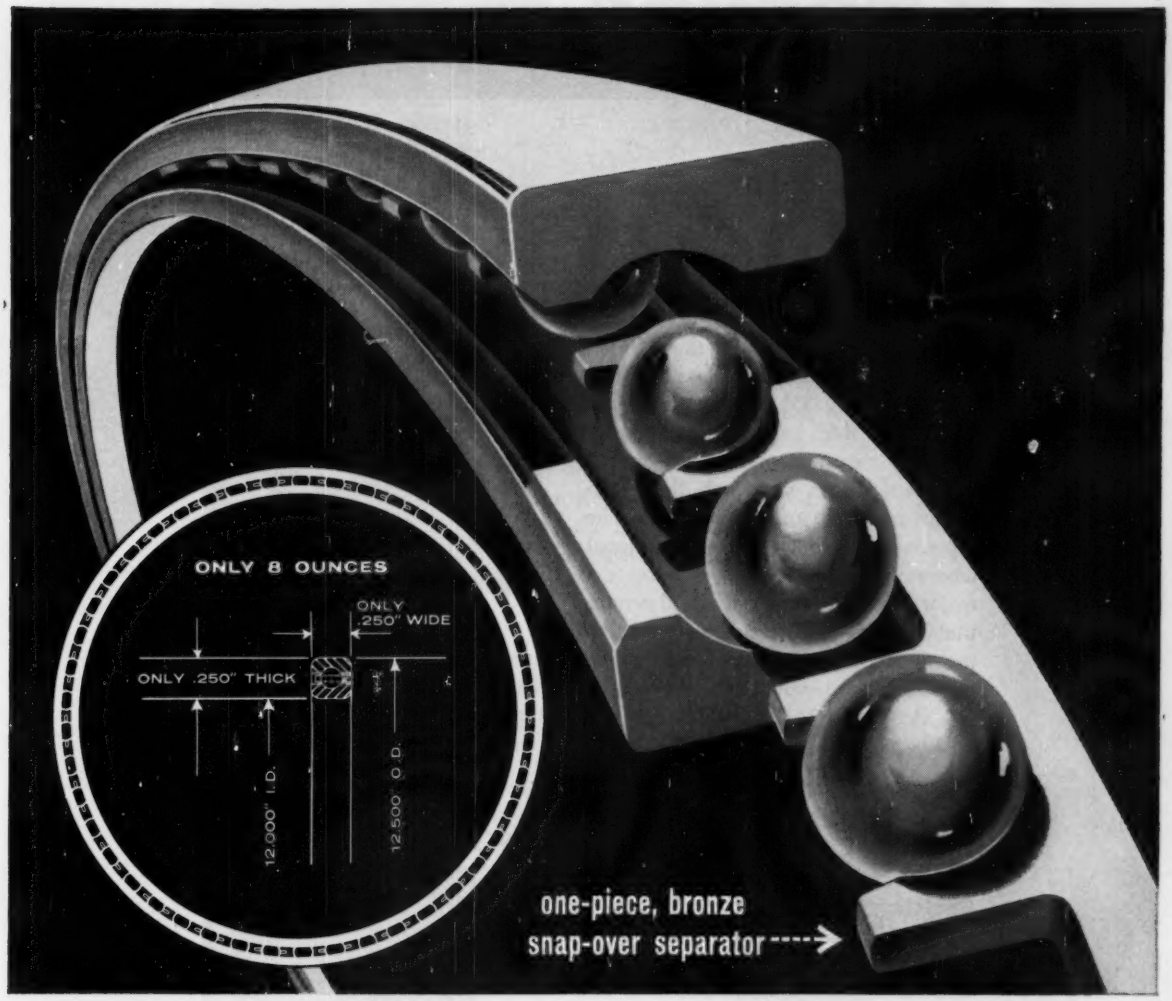

News from KAYDON!

Reali-Slim bearings "off the shelf" ...prices slashed up to 76%

90 sizes — 4" to 12" bore — 1/4" to 1" width and cross-section

Drastic price reductions — on Kaydon new type "CP" Reali-Slim bearings! Volume production and new bronze snap-over separator permit price reductions from 33 to 76%, depending on size.

Save on bearing cross-section and weight — Reali-Slim is the world's thinnest radial ball bearing. Many sizes of type "CP" are less than 15% of the weight, 34% of the width and cross-section of comparable, extra-light bearings.

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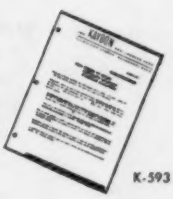

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NEWS TRENDS

tolerance: 0.0000001 inch?

Agreement has been obtained between standards laboratories of the United States, England, Germany, and Sheffield Corp., Dayton, Ohio, on the precise length of a 4-in. gage block. Three of the four measurements agreed within one ten-millionth of an inch, the fourth within one millionth of an inch. The experiment, part of an international laboratory calibration test, represents a major scientific advance. It illustrates that the seventh decimal place can be measured on a commercial basis. An increasing number of parts used in the missile, aircraft, and atomic energy industries require dimensional tolerances this close to zero. Sheffield started the test program to assure the precision-measurement capabilities of its instrument in the U. S. and abroad.

twin arc-light furnace grows better crystals

Bigger single crystals of pure refractory materials are grown at Stanford Research Institute, Menlo Park, Calif., through the use of a special arc furnace. The furnace consists of two arc units face-to-face. The two are separated by a 45-degree control mirror which can be rotated to divert the arc light from either source to a vertical elliptical mirror. The mirror focuses the light energy on top of a growing crystal. Use of two arc units extends growing periods—short life of one arc would prohibit growing the crystals to as large a size as is possible with the two units. For example, clear rutile (TiO_2) $\frac{3}{8}$-in. diam x 1-in. long has been grown in a pure oxygen atmosphere. Currently, SRI is using the equipment to grow high-purity carbide, nitride, and intermetallic single crystals.

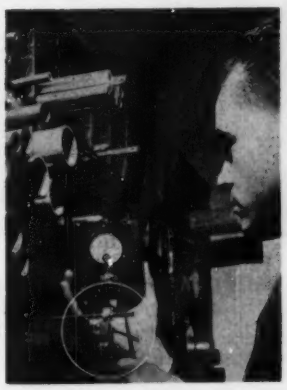
profs guide industry's R & D

The Government's research techniques can work for private companies too, says Thomas R. Jones, president, Daystrom Inc., Murray Hill, N. J. So Daystrom has hired a technical advisory committee of consultants to direct its research and development programs. The committee—made up of professors and scientists from outstanding engineering schools—does two jobs: It reviews and assists in co-ordinating divisional R & D programs, and it provides information on what's new in labs of universities and nonprofit institutions throughout the country. Mr. Jones feels this outside guidance will keep the company aware of what developments are going to be important.

Navy looks for a hot spring

Aircraft powerplants are running too hot for the current crop of spring alloys. Biggest need, according to Navy BuAir specialists, is a spring metal that will hold its load-deflection characteristic reasonably constant over a wide temperature range. Looking into the problem for the Navy, National Bureau of Standards found a shortage of basic data on the thermoelastic properties of metals. To fill the void, NBS devised two new setups for measuring elastic constants at elevated temperatures: One uses an oven-enclosed torsion pendulum to test wire specimens; the second excites furnace-heated rods and prisms with sonic vibrations. Information coming out of the study will presumably lead to some improved spring alloys.

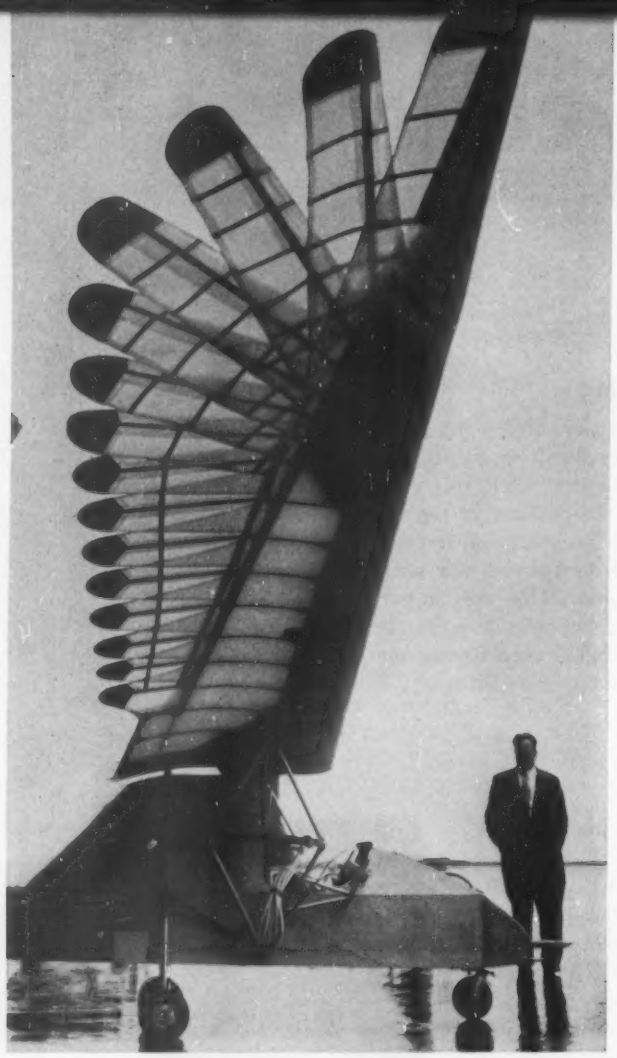
what metal is that?



How do you tell stainless steel from inconel? This is important if you work around a nuclear reactor, because the same spare parts are stocked in both of these look-alike metals. A quick and inexpensive test, developed by George Martin, GE scientist at the Knolls Atomic Power Laboratory, requires only a standard milliammeter with two leads, one attached to a clamp and the other to a small carbon-steel file. After clamping the one lead to the unknown part, Mr. Martin rubs the part with the file (heating it up). Part and file form a thermoelectric hot junction, and polarity of the junction depends on whether the part is stainless or inconel. With one material, the meter needle swings one way; with the other, it swings the other way. The meter also distinguishes between zircaloy-2 and zirconium, and between zircaloy-2 and hafnium, other look-alike reactor materials.

exploding wires bid for heating and lighting jobs

Space communications and propulsion, ignition of thermonuclear reactions, and generation of hypervelocity particles in the laboratory may all become jobs for electrically exploded wires, according to Dr. A. M. Zarem, president, Electro-Optical Systems Inc., Pasadena, Calif. EOS has just completed a feasibility study for the Army Ordnance Corps, and its studies show exploding wires can do many "heat and light" jobs. Key to these applications is the switching of tremendous currents into thin wires in "practically zero" time. Rapid vaporization develops temperatures as high as 100,000 C when voltage is switched across the wire (in about 7 millimicroseconds) and currents of several thousand amperes flow. Vaporization takes place in about 50 to 100 millimicroseconds. Switching is triggered by a hydrogen thyratron which, in turn, activates a trigatron (triggered air-spark gap) that releases the current. Many times the vaporization energy is "dumped" into the wire.



Flapping wing and flycycle, being readied for flight in Britain, represent the continued European interest in man-powered aircraft. Ornithopter (above), a perennial favorite, has 36-ft feathered wings activated through an arrangement of pedals and oar-like handgrips. Designer (and prime mover) Emiel Hartman, a London engineer, may flap to fame if he has solved the old problem of "fatigue" failure. Near sonic, by comparison, is the sleek flycycle (below). It's being built by students at Queen's University, Belfast, under the direction of the school's senior lecturer in aeronautical engineering. The craft will be powered by two small men connected to an 8½-ft pusher propeller. Projected all-up weight is just 500 lb. On take-off "powerplant" will rev up to maximum rpm, then release a clutch. First operational objective (assuming takeoff) is a low-altitude circular flight at a conservative airspeed of 35 to 40 mph.

As an emergency source of fractional horsepower, man may pay his way in space. This practical suggestion, by a prominent scientist, has caught human factors engineers with little knowledge concerning

Man: Low-Power Prime Mover

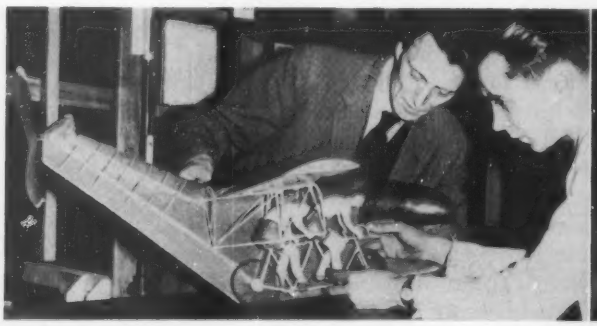
MAN IN SPACE—far from being the pampered master of pushbutton slaves—may wind up cranking and pedaling to supply power for some of the elegant equipment packed in his capsule. According to Ezra S. Krendel, head of Franklin Institute's engineering psychology branch, the orbiting astronaut could help pay his way by eliminating a few pounds of power-generating components.

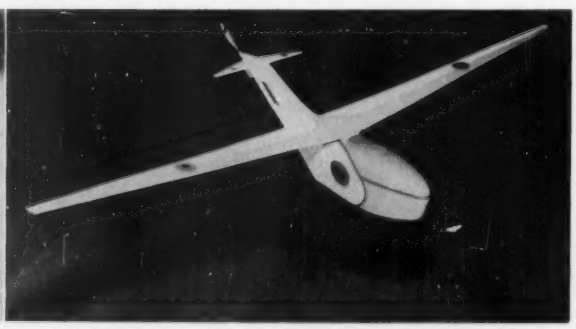
Like every concept considered for space, this one hinges on critical detail. Boiled down considerably, the question is simply this: Exactly how much power can a man produce (by the obvious methods of cranking and pedaling), and for how long? Assuming that the astronaut will be dependable, one of the biggest current questions—reliability—is licked at the start.

In following up his idea, Mr. Krendel has gathered most of the world's significant data on handwheel, crank, and pedal-produced power. While his search shows a dearth of data fine enough for space applications it also points to some logical beginnings and unusual progress.

As a jumping-off point Mr. Krendel suggests that it is possible to develop a theory for optimal power transfer from a man-machine system to the useful load which is analogous to the familiar power-transfer relationships used in electrical engineering.

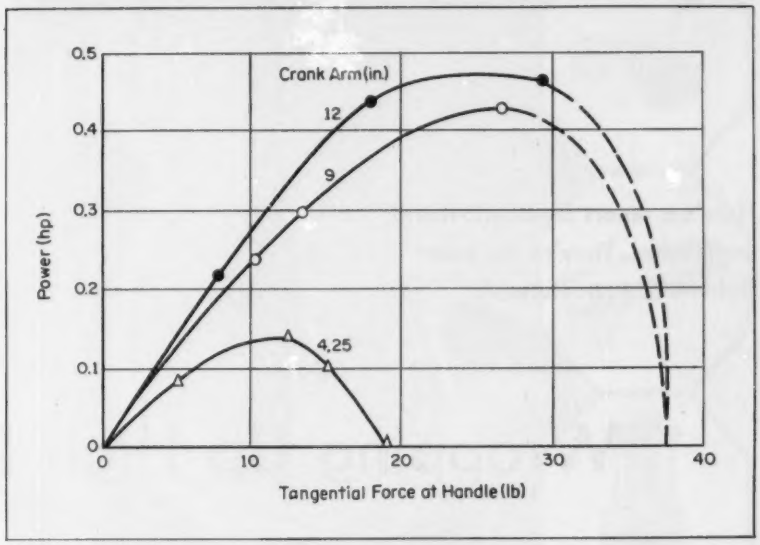
As for practical, everyday data, the following charts sum up most of the research to date on man as a prime mover. . .





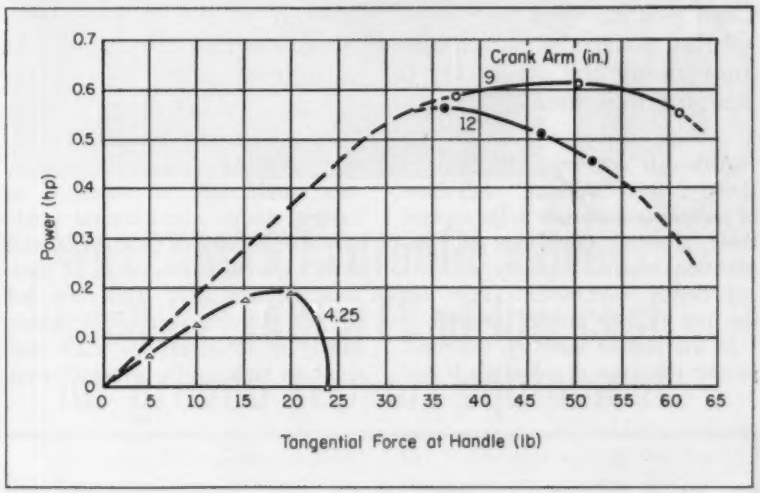
One-handed cranking . . . average power generated over brief intervals

"Twelve young subjects of average physique" provided data for the 4.25-in. crank-handle plot (right). Power was measured from the average rotational speed and torque. Speed at maximum power was about 180 rpm; maximum rotational speed was about 260 rpm. Data for 9 and 12 in. handles are based on cranking efforts of naval recruits. Subjects merely faced the crank and rotated it as fast as possible for total of 30 turns (about 20 seconds). Data recording continued up to the point where subjects spontaneously began two-handed cranking. Maximum power output occurs at 110 rpm for the 9-in. crank; 85 rpm for the 12-in. crank. Limiting speed is about 170 and 150 rpm, respectively.



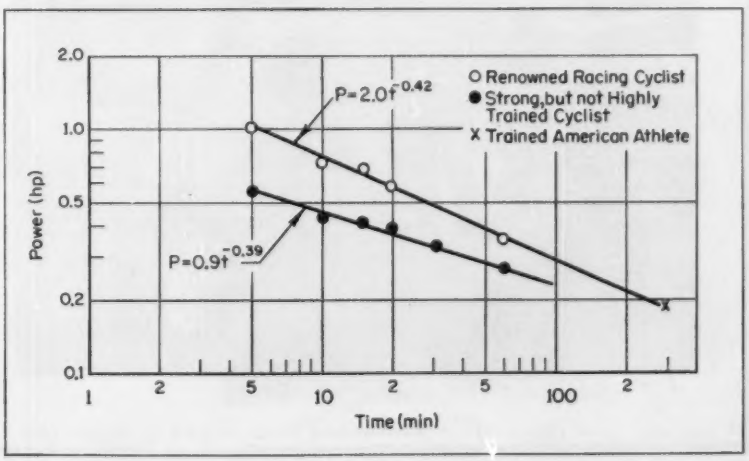
Two-handed cranking . . . average power generated over brief intervals

Little increase in power output is gained in the shift to two-handed cranking. Rotational speed for maximum power output reduces, however, to 85 rpm for the 9-in. crank and 80 rpm for the 12-in. The limiting two-handed speed of rotation is 130 rpm for the 9-in. crank; 100 rpm for the 12-in. Subjects winding the 4.25-in. crank were given two cranks to turn (instead of winding one crank with two hands). Reciprocal winding reportedly caused no problem. Maximum power occurred at 140 rpm; limiting speed was 210 rpm.



Pedaling . . . power generation over long durations

More is known about pedaling than about cranking . . . and not simply because of the bicycle. During the Twenties and Thirties, interest in muscle-powered flight flourished in Germany, France, and Italy. Propellers driven by pedal power were considered a promising means of prolonging the flight of highly efficient gliders. The Germans, as usual, took notes of the proceedings and have preserved some significant data (right). Variables such as crank size, leg motion, average rpm of pedal, and intermittent vs. sustained effort are poorly documented, however, giving human factors experts little to go on.



J. J. SCAVUZZO
Chief, Design and Fabrication Unit
Plastics & Adhesive Research Section
Feltman Research and Engineering Laboratory
Picatinny Arsenal, Dover, N. J.

Here's a report on plastic-metal composites. They're the latest lightweight structures for

Wrapping Up High Pressures

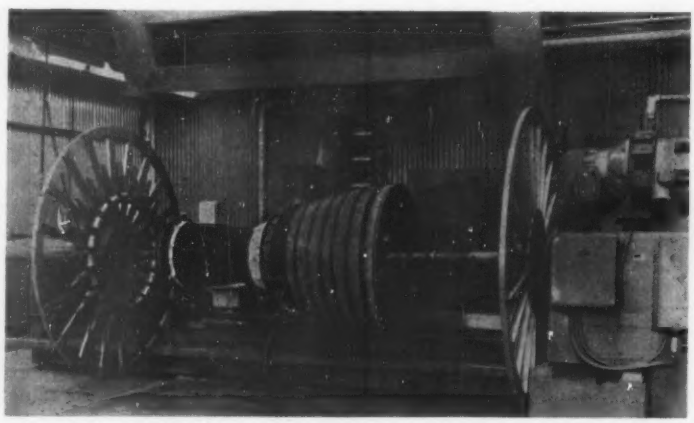
Com·pos·ite—An intentional marriage of two or more dissimilar materials, each retaining its distinctive properties, but augmenting the others for the purpose of satisfying specific design requirements.

Although not found in the dictionary, this "working" definition of composite materials helps explain their growing popularity in applications where complex or conflicting design requirements rule out the use of any single material.

In the plastics industry, the compatible marriage of materials is not new. Without composites, fabricators would still be restricted to casting simple nonstructural products like jewelry, billiard balls, and toys. Use of fillers, such as cord, asbestos, and glass fiber, has led to the development of a whole family of structural materials that combine high specific strengths with the inherently desirable properties of plastics.

Glass-fiber reinforced plastics have very high specific strengths (strength-to-weight ratios) and have repeatedly demonstrated their usefulness in structural applications. However, extensive use of these materials has been limited by their poor moduli (1,000,000 to 5,000,000). This is often a serious disadvantage because the stiffness factor *EI* is usually important in structural design. A considerable amount of research and development work

Glass wrap for a rocket . . .



Rocketdyne (division of North American Aviation, Inc.) is an old hand at beefing up rocket thrust chambers with glass wrappings. The process saves 56 lb on an Atlas engine, can be completed in 8 hours at a cost saving of 25 per cent over steel-banded and welded engines. Rocketdyne rotates the chamber in the jig shown here. Glass-filament roving, impregnated with epoxy resin, is wound around the thrust chamber over a base composed of longitudinal glass-tape sections. After wrapping, the chamber cures for 2 hours at 200 to 300 F.

is aimed at improving the moduli of resin and glass-fiber composites.

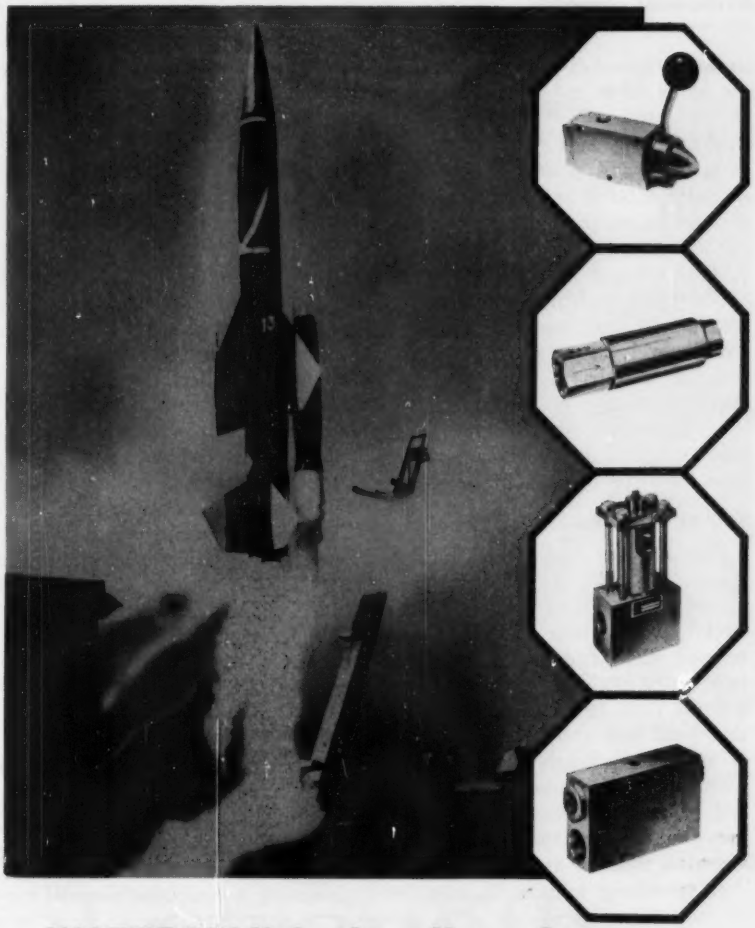
Doubling the Burst Pressures

Demands for high specific strength materials with high moduli are now being satisfied by "arranged marriages" of resins, metals, and glass fibers. In these composites, the plastic acts as a binder for the reinforcing material. The metal can be either monolithic, strip, or wire, and can be high or low-strength steel, aluminum, or titanium.

Combination of monolithic metal structures, and glass-fiber reinforced plastics compensates for the structural disadvantages of reinforced plastics. Such plastics when used alone do not transmit localized or bending stresses well, principally because they do not exhibit the ductility obtainable with structural metals. In addition, their properties are directional in nature.

A plastic-metal composite well suited for pressure vessels consists of an inner shell of ductile material (metal), completely encased in a glass-filament outer shell. The metal shell resists longitudinal loads; the glass-fiber layer, wound in hoop only, augments the hoop strength of the composite structure. Pressure vessels of this construction will rupture in longitudinal failure, not normal hoop failure.

Glass-fiber reinforced plastics have exhibited stress levels beyond 150,000 psi at rupture, thus demon-



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strating that the full strength of the glass fiber is being realized. In fact, the burst pressure of a steel pressure vessel reinforced with glass fiber and plastic can be essentially doubled with only a slight increase in weight (glass-reinforced plastic has a density of 0.068 lb per cu in. compared to 0.283 for steel).

The most restrictive limitation of plastic-metal composites is the comparatively low operating temperature of the resins. Any application which requires an operating temperature above 275 to 300 F for an extended period cannot be considered for this material system.

Bonding the Ribbon Steels

Demands for higher and higher specific strengths have forced designers to project design stresses in steel to values near maximum developed yield strengths. Improved technology has made possible 200,000 psi yield strength steel, but at this level and above, the material is subject to brittle type failure. This places limitations on missile and rocket-case designers who must use the highest specific strength materials that are available.

A promising solution is seen in the development of ultra-high-strength metallic strip structures, assembled by a ribbon-wrap, plastic-bonding process. In this composite, narrow (1 to 6 in. wide), thin (0.003 to 0.009 in. thick) steel strip is helically wound around a mandrel, then followed by a second layer bonded to the first by an adhesive. Wrapping is continued until the desired helical-layer thickness is obtained.

This structure is the only one which can effectively utilize the design potentials of ultra-high-strength steel ribbon. However, other, more common metals and combinations of metals and glass-reinforced plastics can also be used. The most frequently used steel is one similar in composition to AISI C-1065 with 2 per cent nickel added. This steel has an ultimate tensile strength of 325,000 psi. The adhesive is an epoxy, applied in layers 0.001 to 0.002 in. thick.

Also Under Test

Aluminum strip (7075-T6) with an ultimate tensile strength of 76,000 psi has also been tentatively evaluated at the Ordnance Corps Laboratory and shows promise of producing a composite material system with higher specific strengths than plastic-bonded steel-strip laminates.

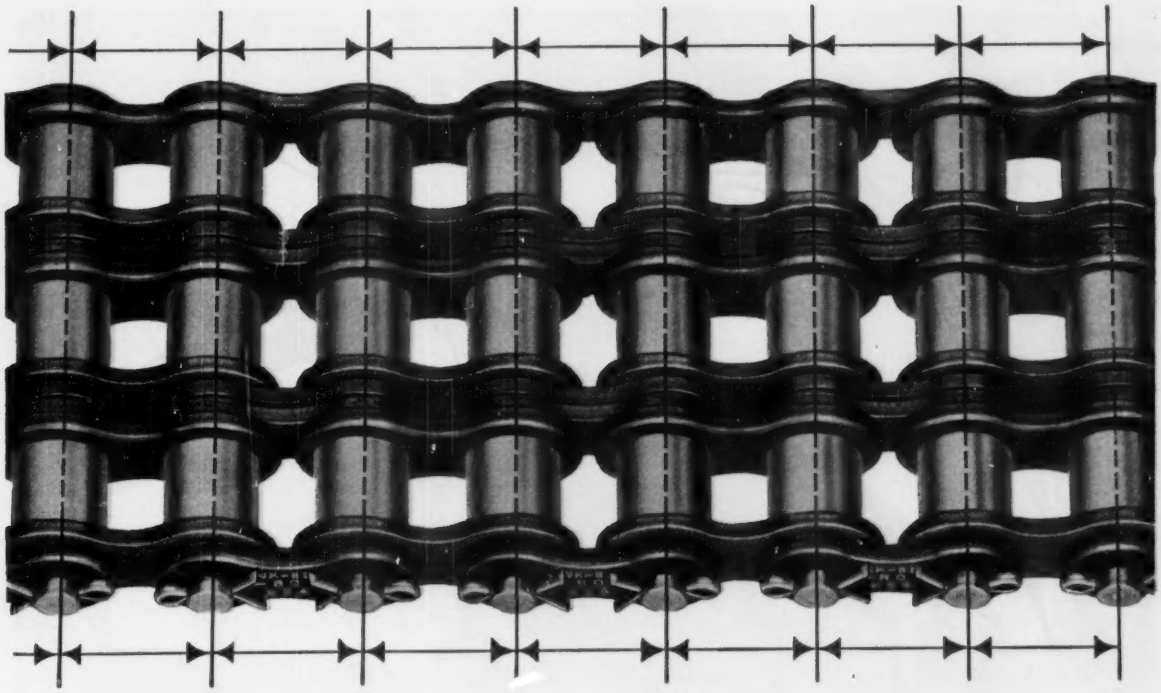
North American's Rocketdyne division has proved out the glass-filament wrapping process with a variety of solid-fuel rocket-motor cases and pressure tanks. This helically wound tank has a volume of 2200 cu in.

Again, as with monolithic-steel and glass-fiber composites, the major problem with strip-metal

Testing metal-plastic pressure vessels . . .

Material	Wall Thickness (in.) Metal	Glass	Total	Burst Pressure (psi)	Composite Hoop Stress (psi)	Stress in Metal At Rupture (psi)	Increase in Metal Ultimate Strength (per cent)
Hoop Stress Only:							
4130 steel	0.034	....	0.034	....	113,000	113,000	0
4130-glass	0.034	0.013	0.047	....	150,000	149,000	32
4130-glass	0.034	0.029	0.063	....	140,000	129,000	14
4130-glass	0.034	0.039	0.073	....	155,000	154,000	36
1015 steel	0.034	....	0.034	....	87,000	87,000	0
1015-glass	0.034	0.044	0.078	....	141,500	125,500	44
1015-glass	0.034	0.029	0.063	....	140,000	129,000	48
Hoop and Longitudinal Stresses:							
4130 steel	0.012	....	0.012	1400	114,000	114,000	0
4130-glass	0.012	0.018*					
		0.012†	0.042	5300	123,500	183,000	60
4130-glass	0.0085	0.021*					
		0.012†	0.0415	4550	110,000	165,000	44

*Hoop wrap. †Longitudinal strips.



Equal length... equal strength

How pre-stressing ensures uniform load distribution of multiple-width LINK-BELT roller chain

Pre-stressing is one of the reasons why Link-Belt multiple-width precision steel roller chains easily handle the grueling loads common on today's drives. It seats and cold works the chain joint parts, assuring equal load distribution across the chain, minimum initial elongation, increased fatigue life.

Pre-stressing is just one of many "extras" that contribute to the *greater dynamic strength* of Link-Belt roller chain. Others include: close heat-treat control, lock-type bushings, shot-peened rollers, pitch-hole preparation. For details see Book 2657.

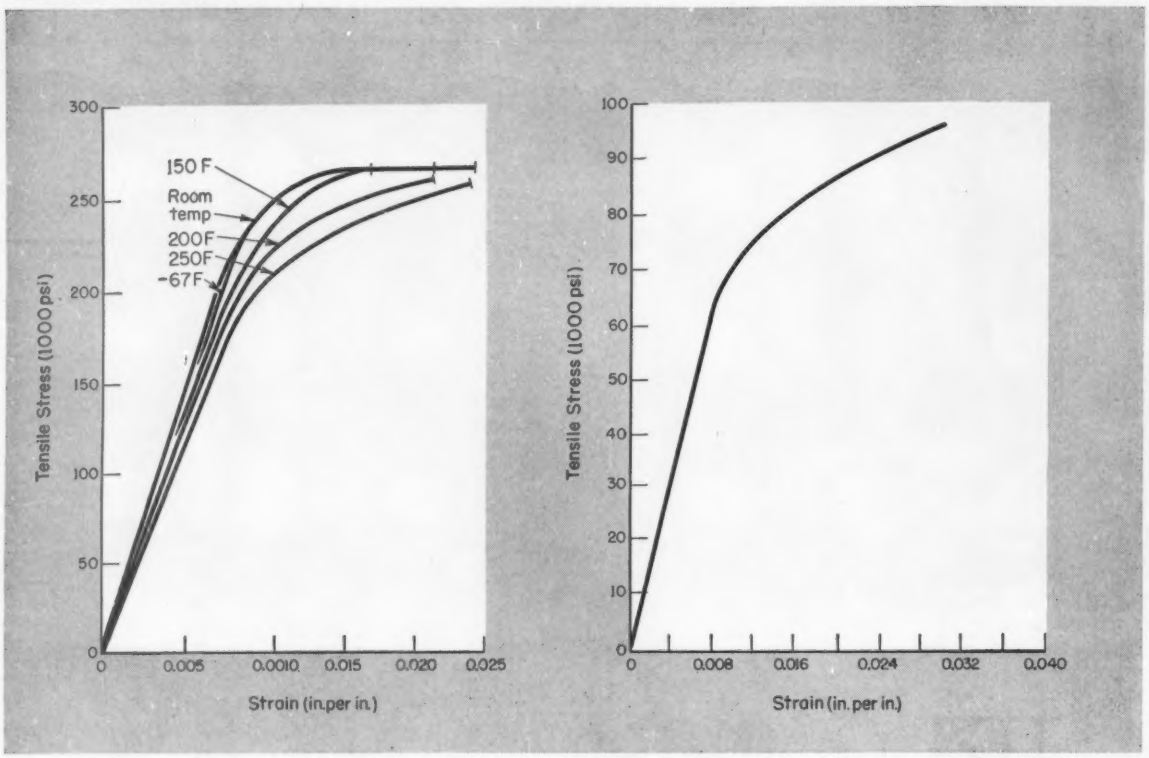
PRE-STRESSING MACHINE provides the pull that "sets" the parts of Link-Belt multiple-width roller chain. Besides assuring uniform load distribution, pre-stressing eliminates application difficulties on fixed center drives because the chain leaves the factory at precise operational length.

LINK-BELT

ROLLER CHAINS AND SPROCKETS

BOOK 2657 has 154 pages of roller chain data. Contact your nearest Link-Belt office. (See CHAINS in the yellow pages of your classified phone directory.)

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney); Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World.



Stress-strain characteristics of an epoxy-bonded, high-strength ribbon-steel composite. Laminate consisted of 8 plies of 0.008-in. thick steel, bonded with 0.001-in. adhesive layers. Strain is based on total cross-section area; strain rate was 0.05 in. per minute.

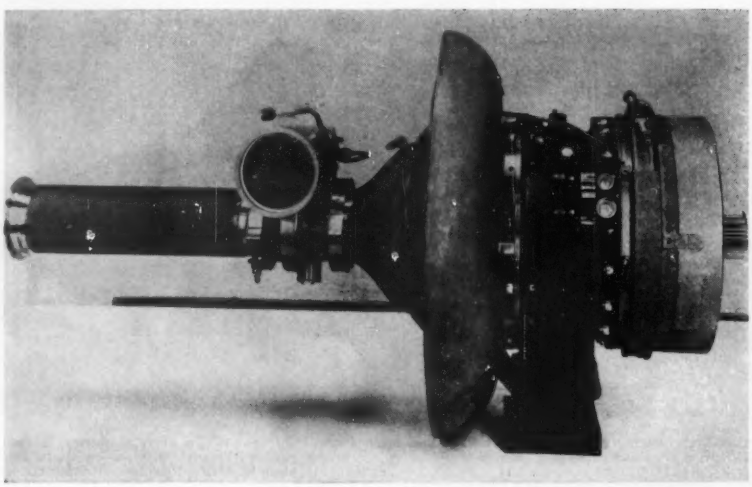
Stress-strain curve for an epoxy-bonded aluminum-strip laminate at room temperature. Aluminum alone (7075-T6) has an ultimate strength of 76,000 psi. Stress plotted is based on total cross-section area. Composite density is 0.083 lb per cu in. Strain rate was 0.05 in. per minute.

fiberglass structures is the limiting temperatures of the adhesives. Ceramic-type adhesives with high temperature resistance are available, but these do not have the high shear strengths required to support the system.

The Ordnance Corps Plastics Laboratory is also attempting to obtain high specific strengths and high moduli by combining high-strength steel filaments and glass-filament-reinforced plastics. It is hoped that this development will also lead to composites that compensate for the structural deficiencies of all-fiberglass reinforced plastic structures.

Starter's Ready . . . Where's the Airplane?

Bringing a nuclear airplane's turbine up to self-sustaining speed will be the job of a new 500-hp starter and motoring unit. Developed by General Electric's Aircraft Accessory Turbine Dept., Schenectady, N. Y., the unit will do its starting work in about one minute, then will loaf until the main powerplant is shut down. At this time it keeps the turbine turning over (motoring) to dissipate powerplant heat during the several-hour cooling-off period. Designed to operate in a radioactive environment, the starter is fed 700 F, 80 psia air by a ground unit or by engine cross-bleed in flight. Main components include a pressure-regulating inlet valve, a two-stage axial-flow turbine, a speed-reduction gear box, and an over-running clutch.



DO YOUR MOLDED COMPONENTS GIVE YOU HEADACHES?

Compound dilemmas? Should it be Neoprene . . . Buna-N . . . VITON* . . . Silicon or Polyacrylic? How about temperature . . . below zero or sizzling? Unusual pressure conditions? . . . or perhaps a highly destructive hydraulic fluid?

If compound . . . temperature . . . pressure *or* the medium bring unusual problems to your drawing board call on IPC. Our "custom" approach to *your* application is strengthened by broad experience in the use of materials and molding techniques.

Strict attention to detail is an IPC hallmark. We welcome problem solving. Ask your IPC representative to show you samples of some unusual headaches we've cured.

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INTERNATIONAL PACKINGS CORPORATION

Bristol, New Hampshire

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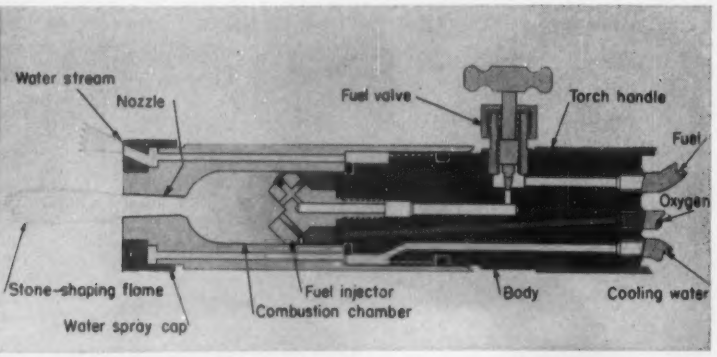
P-2

New Flame Updates an Old Process



Spitting fire—as hot as 5500 F—at the rate of 7000 fps, a new torch with an afterburner-type flame carves and shapes stone five times faster than mechanical methods. The combination of intense heat and high velocity causes stone to spall, or break up into chips. Mechanical energy equivalent of the flame at its highest velocity is 25 hp. The flame is produced by burning oxygen and kerosine in an internal water-cooled chamber in the front end of the torch. Reducing the fuel ratio provides a small, sharp jet for precise work. Because stress and shock are eliminated, slabs as thin as $\frac{5}{8}$ in. can be shaped without cracking. The 37-in., 7-lb Oxweld Stone-Shaping torch is made by Linde Co., Div. of Union Carbide Corp.

Britain Gets a First: Robot Power Station

Remote-Control Substation Is Serving 10,000 People

BRISTOL, ENGLAND—A remotely controlled electric power station—the only one of its kind in the world—is now operating in England. It generates 3000 kw with a modified Bristol Proteus engine—the aircraft turbine that is standard equipment on Bristol's Britannia airliner.

The turbogenerator weighs only 2240 lb, runs silently, requires no cooling water, and starts rapidly without a warm-up period. The pocket-size power station can be built of brick and/or stone and is no larger than a house—35 ft x 23 ft x 20-ft high. Remote control is achieved through a newly developed system which operates over public telephone lines. The remote operator dials the station to start the generator, then monitors power meters and "gives orders" all by telephone.

Although unsuitable for continuous running, say British experts, robot stations are believed to make excellent substations. Should the main supply fail, they will prevent local breakdowns.

Radar's Computer Puts Out Chartable Data

Radar target tracks can be charted accurately at NASA's Wallops Island Range. A new computer that has now been operational for 1000 hours presents data in X-Y co-ordinate form. The computer, designed by Computer Systems Inc., New York, for use with all operational radars, automatically computes range, elevation, and azimuth data, then presents range and azimuth data in cartesian co-ordinates. It compensates for the earth's curvature and contains calibrated parallax and scale-factor controls. Plot parallax, inserted in the computer's output, permits the switching of radar locations for greatest gain and resolution. This makes plotting possible from a group of remote radars tracking a target over a long flight path and permits maximum resolution in plotting computed data.

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STAINLESS STEEL PLATE . . . rolled to almost any size or thickness, 3/16" and heavier, to meet your individual needs—whether rectangles, circles or special patterns. Substantial tonnage in Types 302, 304, 304-L, 309, 309-S, 310, 316, 316-L, 317, 317-L, 321, 347, 348, 405, 410, 430 and 502-½% Mo. is available for prompt delivery. In addition, two precipitation-hardening grades, Types 17-4 PH* and 17-7 PH* are now in production.

STAINLESS STEEL HEADS . . . in Types 304, 304-L, 316 and 316-L are available from stock in ASME and Standard specifications (10" to 72" diameter). A large assortment of dies is available for pressing other types of heads and special sizes can be spun where practical.

STAINLESS STEEL FORGINGS and SPECIAL PATTERNS . . . including tube sheets, flanges, circles, rings, sketch plates and other specialties can be produced to specification on our versatile equipment.

Also STAINLESS STEEL BARS AND SHEETS (No. 1 Finish).

*Trade mark of ARMCO STEEL CORPORATION

PLATES • PLATE PRODUCTS • HEADS • RINGS • CIRCLES • FLANGES • FORGINGS • BARS and SHEETS (No. 1 Finish)

Circle 417 on Page 19

Sheets of Paint . . . and Sheets of Glue

Predried sheets of paint and glue will take the mess out of many industrial jobs. The finish, developed by Morgan Adhesives Co., Stow, Ohio, consists of a layer of pure paint backed up with a pressure-sensitive adhesive. The sheet comes in sandwich form, sealed between two layers of paper. Painting by this method consists of cutting the sheet to fit the surface area, stripping the paper off the adhesive side, positioning the piece, applying pressure, and removing the surface layer of paper. The glue is a new film-supported adhesive developed by Reichhold Chemicals Inc., Seattle. A sheet of adhesive is placed between two surfaces, and the bond is cured either in a hot press or by high-frequency field heating. At normal temperature and humidity, layups waiting to be joined can be stored for considerable periods before pressing. Besides being clean and easy to handle, the new glue keeps moisture out of joints.

Mobile Missile Manipulator

Transrector—an 80-ton mobile handling unit developed by the Siegler Corp., Hufford Div., El Segundo, Calif.,—transports rocket engines to test areas and places them in position for static firing. Basically a tractor with a special trailer, the unit is capable of handling 40-ton engines that are up to 35 ft long. Its hydraulically actuated mechanisms and electric hoists respond instantaneously and permit movements of a fraction of an inch at a time.

Revolution (Industrial) Has Come, Says Professor

CLEVELAND—Dr. Melvin Kranzberg, Professor of History, Case Institute of Technology, believes that we are in the midst of a new industrial revolution. To prove his point, Dr. Kranzberg cites criteria which are presently used to identify past industrial revolutions:

Man's use of basic materials. The use of copper tools instead of stone ones for example, created demands for specialized industries, organized trade, and additional food to support workers producing tools.

New uses of fuels and prime movers. The classic Industrial Revolution of the eighteenth century is associated with expanded use of coal and the invention of the steam engine. But the new power sources followed, rather than preceded, this industrial revolution. According to Dr. Kranzberg, changes in materials, machines, and the organization of labor actually resulted in the power increase associated with the steam engine.

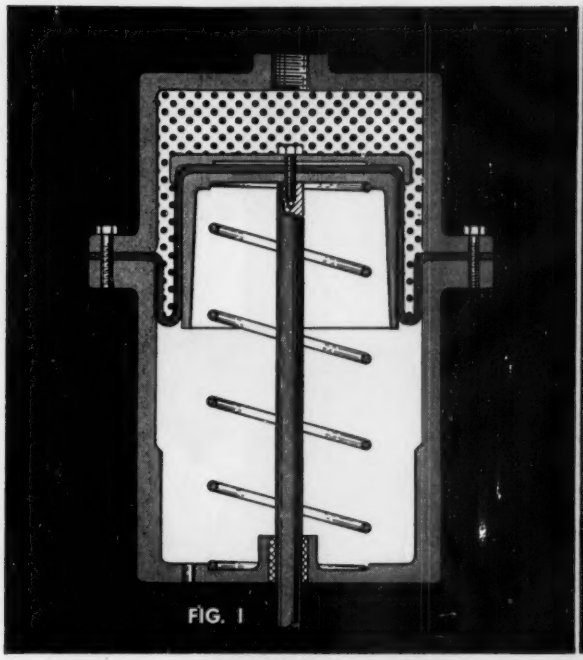
Application of tools and machines. These are very closely connected with other technical factors as well as broad sociological developments —capital accumulation, for example, played a major role in the application of tools and machinery during the eighteenth century.

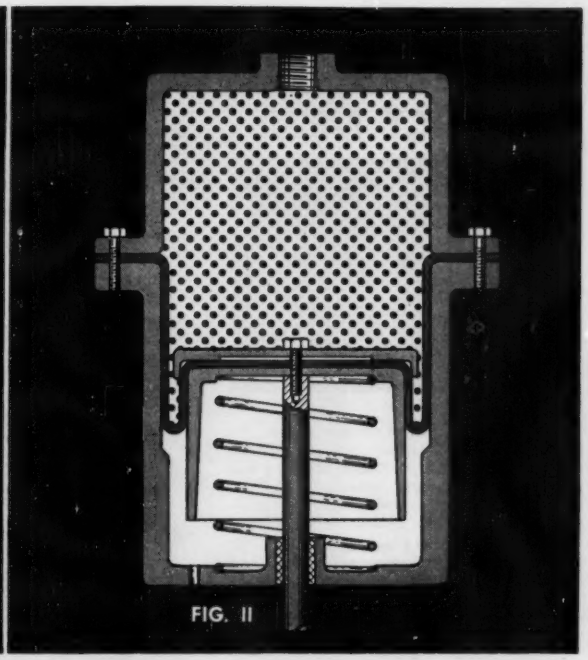
Techniques of production and organization of labor. The Industrial Revolution of the 1700s not only developed the factory system, but it changed workers from tool manipulators to machine operators.

Improvements in transportation and communication. The prehistoric industrial revolution (5000 B.C.) saw first use of wheels, draft animals, and sails, as well as the introduction of writing.

Application of science to the ends of technology. Until the middle of the nineteenth century, science as such had little impact upon industrial development. Since then, however, it has become so important that large-scale industrial achievements are inconceivable without scientific contributions.

Applying these six standards to the present period, we find: Use of rare-earth and lightweight metals, new alloys and synthetics; new





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Rolling Diaphragm. It's frictionless!

The Bellofram Rolling Diaphragm provides ultra-sensitive response in hydraulic or pneumatic devices where frictionless, long-stroke action in small diameter configurations is required . . . and where flex life of millions of cycles is necessary.

These desiderata are achieved through the *rolling* action of a flexible, thin-sidewall diaphragm consisting of a high-tenacity fabric overlay embedded in elastomeric material.

Fig. I shows how Bellofram Rolling Diaphragm conforms to the piston. Fig. II shows how, as the piston descends under pressure, the Bellofram Rolling Diaphragm *rolls* off the piston's sidewall and onto the cylinder's sidewall in a smooth, continuous, frictionless movement.

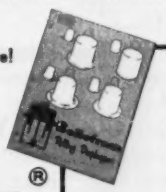
The Bellofram principle can be applied widely in actuators, pumps, instruments, seals, accumulators, and fluid dampers.

Which of these advantages are you looking for?

To the designer confronted with situations for which conventional bellows, O-rings, or cup packings are inadequate, Bellofram Rolling Diaphragm offers a constellation of advantages found in no other product:

1. **Friction-free (low hysteresis).**
2. **No break-out friction effects.**
3. **Non-porous and leakproof.**
4. **Constant area in all piston positions.**
5. **Almost infinite flex life (millions of cycles).**
6. **Sensitivity to extremely small pressure changes.**
7. **No mechanical spring gradient.**
8. **Compatibility with practically all environmental gases or fluids.**
9. **Automatic de-icing action.**
10. **Free positioning with complete relaxation at any point in the stroke.**
11. **Does not require close machine finish tolerances on pistons and cylinders.**
12. **Freedom from abrasive wear.**
13. **One hundred stock sizes. Four mounting configurations. Special types and sizes designed to order.**
14. **Excellent temperature stability from —85°F. to 550°F. (from —120°F. to 700°F. in some cases). Wide range of working pressures: 1 inch H_2O to 500 psi (up to 1200 psi in some cases). Effective pressure areas from .028 to 108 square inches. Cylinder bore diameters from .25 to 12 inches. Extended range of stroke (.01 to 12 inches).**

Send for **FREE BROCHURE** that tells you more!



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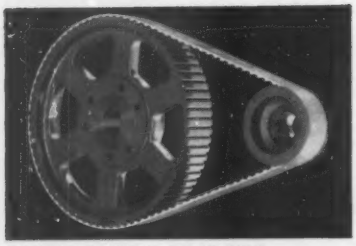
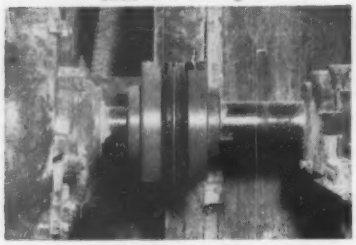
WOOD'S POWER TRANSMISSION PRODUCT NEWS



POSITIVE ACTION—LONG LIFE

Wood's Timing Belt Drives provide positive, slip-free action. Belts are all muscle. No high initial tension, tension devices or lubrication needed. Drives are light weight, compact... quiet and clean. Wide load and speed range. Equipped with famous Sure-Grip Bushings. Write for Bulletin 2100.

Circle 418 on Page 19



4-WAY FLEX—UNIQUE DESIGN

Wood's Sure-Flex Couplings absorb 5 to 15 times more shock and vibration than other leading flexible couplings... swallow all types and combinations of angular and parallel misalignment, end-float. Simple, no wear, no lubrication. Low cost. Write for Bulletin 5103.

Circle 419 on Page 19

REVOLUTIONARY NEW VARIABLE

Revolutionary resilient cam follower construction of Wood's new "MCS" motion control, variable speed drives holds constant driven speeds under varying torque loads. Like the "MS," the "MCS" won't freeze or stick. Check oil only once or twice a year. Write for Bulletins 8102, 4101.

Circle 420 on Page 19

MP/360A

Woods

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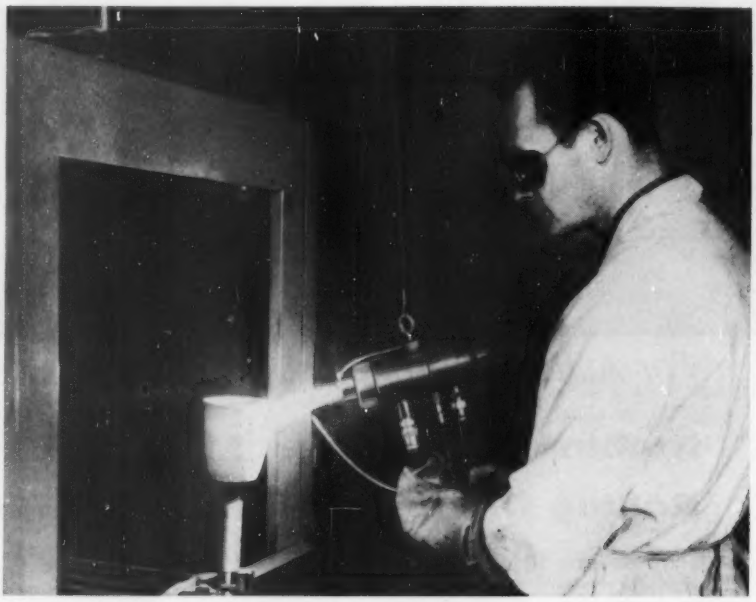
types of power, especially nuclear power and the possibility of solar power; increasing use of automation, with the prospect of a virtually all-automated factory; and developments in radio, television, air travel, and promise of space travel. All these developments are in turn based on the increasing application of science.

All requirements seem to have been met, but as Dr. Kranzberg points out, history alone will be able to tell whether or not we are living in the midst of a genuine industrial revolution.



Plasma Gun Cuts Metal-Spray Costs

First plasma torch to appear on the market is a spray gun. Developed by Metallizing Engineering Co. Inc., Westbury, Long Island, N. Y., the gun produces continuous gas streams as hot as 30,000 F. A mixture of nitrogen and 5 to 10 per cent hydrogen is passed through an electric arc, dissociated, and ionized to form the plasma within the nozzle. Both nozzle and gun body are water-cooled to protect the torch and the operator from the tremendous heat generated. Metal or other material to be sprayed is added in powder form directly to the plasma stream. Temperature control is accurate, and heat can be generated for a cost of one-third to one-half that of oxygen fuel gas equipment, says a Metco spokesman. Other advantages: Pushbutton control, simplicity, and safe operation.

Meetings and Shows

Feb. 14-18—

American Institute of Mining, Metallurgical, and Petroleum Engineers. Annual Meeting to be held at the Statler-McAlpin Hotel, New York. Further information is available from AIME headquarters, 29 W. 39th St., New York 18, N. Y.

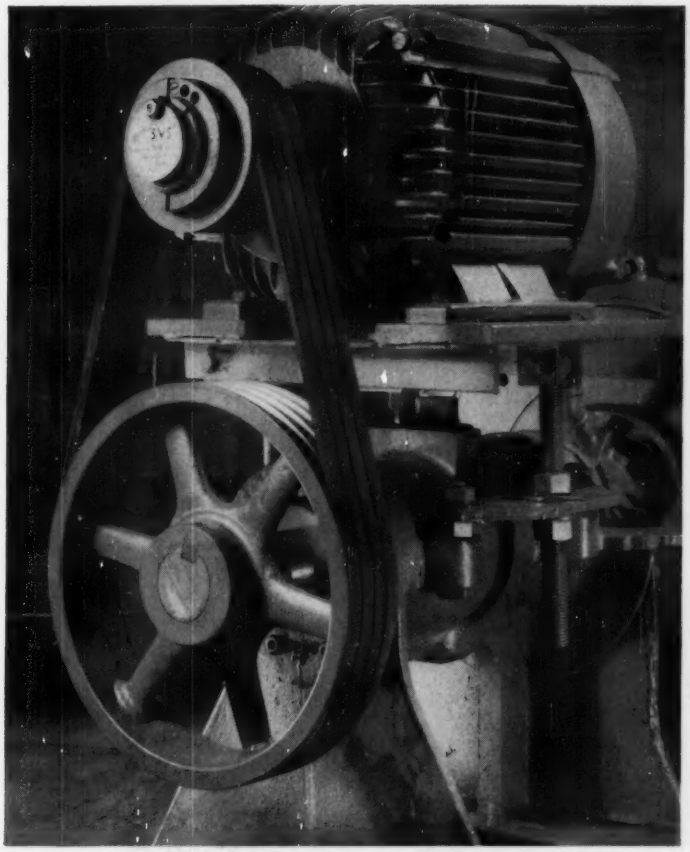
Feb. 16-18—

First National Symposium on Nondestructive Testing of Aircraft and Missile Components to be held at the Hilton Hotel, San Antonio, Tex. Sponsors are the Southwest Section of the Society for Nondestructive Testing Inc. and Southwest Research Institute. Further information is available from William E. Cory, General Chairman, Southwest Research Institute, 8500 Culebra Rd., San Antonio 6, Tex.

Feb. 17-18—

Malleable Founders Society. Fifth Technical and Operating Confer-

(*Please turn to Page* 41)



Patented construction eliminates fretting corrosion, freezing and the need for lubrication.

New Wood's "SVS" Variable Speed Sheave won't freeze . . . needs no lubrication!

Wood's new "SVS" variable speed sheave won't freeze . . . needs no lubrication. Positive locking collars, which cannot be over-tightened, securely clamp split flange extensions into place, eliminating fretting corrosion. Patented design features assure quick, easy speed adjustment. You simply loosen the two locking collars and turn the adjusting screw from either side.

Wood's "SVS" is a stationary control, multiple groove sheave which uses standard v-belts and stock driven sheaves. It is of simple, highly efficient design and sturdy construction, accurately balanced to assure smooth operation and long drive life. Installation is easily made on stub or through shafts. Drive capacities range from 10 to 150 horsepower. Get the complete story.

Wood's

Write for bulletin 6102

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SVS/160

Circle 421 on Page 19

Circle 422 on Page 19→

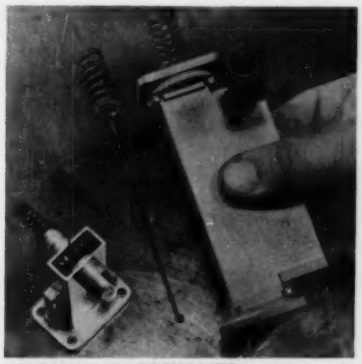
NS SPECIAL WIRE KEEPS SPRINGS ALIVE IN 1400° BATH

When a leading manufacturer of microwave assemblies and radar components was faced with a serious production bottleneck in a high-temperature dip-brazing operation, they came to National-Standard for help in solving the problem.

CRITICAL MICROWAVE ASSEMBLIES being brazed in a 1400° salt bath were held together by cumbersome weights and intricate fixtures that frequently caused distortion or slippage during the brazing operation. The solution—and a considerable time and money saver—was to clamp all the components with springs that would allow expansion of the various parts during brazing without distorting the assembly. However, conventional spring wire would not retain tension at 1400°. Once used, springs had to be discarded.

NATIONAL-STANDARD ENGINEERS, working with the manufacturer's engineers, tested a new superalloy spring wire, NS-25 (L605), that proved "as good as new" after several hundred brazing operations at 1400° F. The mechanical stability of NS-25 spring wire insures proper expansion of parts during heating and maintains just the right tension to give mating parts good contact and perfect bond. The result is manufacturing that is simplified, faster and more precise than was previously possible.

EXPERIENCED ENGINEERING HELP of this kind, for jobs requiring high-quality wire, to meet special or unique applications, is available to you from National-Standard. Write for additional information to National-Standard Company, Niles, Michigan.



MICROWAVE ASSEMBLIES are held together in 1400° brazing bath by springs made of NS-25 wire. This special alloy wire allows rapid, precise brazing never before possible.

NS NATIONAL-STANDARD COMPANY

Manufacturer of Specialty Wire and Metal Products

NATIONAL-STANDARD COMPANY

Niles, Michigan

"From transistor radios to computers—one of National's 115 materials and grades will give you optimum performance in your design."

Why go on a wild goose chase from supplier to supplier for the special plastic material you need for your design? A time- and trouble-saving check with National gives you unbiased help and a material best suited to your property requirements.

National offers the broadest line of basic engineering materials in the industry . . . over 115 materials and grades. You can select the *one best material* to fit your design electrically . . . mechanically . . . chemically. For example:

If you are looking for a new printed circuit material with self-extinguishing properties against fire, National offers XXXP-475. It is made without costlier resins—can be punched at warm temperatures (130° F.—150° F.).

Vulcanized Fibre, extruded thermoplastics and PHENOLITE® laminated plastics offer a wide range of property combinations, such as high electrical-mechanical values plus excellent water absorption and dimensional stability characteristics. Or, electrical properties plus rigidity and heat resistance. Or, electrical properties plus chemical resistance and dimensional stability under load.

You will also find three other important "properties" at National: an understanding of your needs; a willingness to work *with* you; and a facility to fill your requirements fast and efficiently.

You can obtain National materials in standard forms—sheet, tube, rod—in precision fabricated parts to your design, or special-molded polyester shapes. For objective assistance, contact your nearby National Sales Engineer today. Or write us direct, Dept. G-1, Wilmington, Delaware.

CHOOSE FROM THESE MATERIALS...

Vulcanized Fibre: 10 standard grades; many special grades.

PHENOLITE® Laminated Plastic: over 80 standard and modified grades; paper, cotton fabric, nylon, asbestos, glass fabric, cotton and glass mat bases; phenolic, melamine, polyester, epoxy, teflon or silicone resins.

PEERLESS Electrical Insulation: coil, strip, corrugated.

Extruded Nylon, "Delrin", "Ponton": rod, strip, tubing, special shapes.

Polyester Glass Mat: 4 standard sheet grades; custom molded shapes.

PHENOLITE Copper-Clad Laminates: 10 standard grades.

Combination Materials: Rubber-PHENOLITE; Rubber-Fibre; Wood-Fibre; Metal-Fibre; Asbestos-Fibre; PEERLESS-PHENOLITE.

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(Continued from Page 36)

ence to be held at the Wade Park Manor, Cleveland. Additional information can be obtained from society headquarters, 781 Union Commerce Bldg., Cleveland 14, Ohio.

Feb. 18-20—

National Society of Professional Engineers. Winter Meeting to be held at the Broadview Hotel, Wichita, Kans. Additional information can be obtained from NSPE headquarters, 2029 K St. N.W., Washington 6, D. C.

March 6-9—

American Society of Mechanical Engineers. Gas Turbine Power and Hydraulic Conference to be held at the Rice Hotel, Houston. Additional information can be obtained from ASME, 29 W. 39th St., New York 18, N. Y.

March 7-8—

Steel Founders' Society of America. Annual Meeting to be held at the Drake Hotel, Chicago. Further information can be obtained from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

March 14-18—

National Association of Corrosion Engineers. Annual Meeting to be held in Dallas. Additional information is available from NACE headquarters, 1061 M & M Bldg., Houston 2, Tex.

March 15-17—

Society of Automotive Engineers Inc. National Automobile Meeting to be held at the Sheraton-Cadillac Hotel, Detroit. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

March 21-24—

Institute of Radio Engineers. National Convention and Radio Engineering Show to be held at the Waldorf Astoria Hotel and the Coliseum, New York. Further information is available from IRE headquarters, 1 E. 79th St., New York 21, N. Y.

March 22-24—

Society of Automotive Engineers Inc. National Production Meeting to be held at the Statler Hilton Hotel, Cleveland. Further information is available from society headquarters, 485 Lexington Ave., New York 17, N. Y.

March 29—

Material Handling Institute Inc. Spring Meeting to be held at the Pittsburgh-Hilton Hotel, Pittsburgh. Additional information can be obtained from Hanson & Shea Inc., 1 Gateway Center, Pittsburgh 22, Pa.

March 29-31—

22nd Annual American Power Conference, sponsored by Illinois Institute of Technology in co-operation with a total of 23 technical societies and educational institutions, to be held at the Hotel Sher-

"I don't care who you are—you can't get in without a pass!"

man, Chicago. Further information is available from conference director R. A. Budenholzer, Mechanical Engineering Dept., Illinois Institute of Technology, 3300 Federal St., Chicago 16, Ill.

April 4-7—

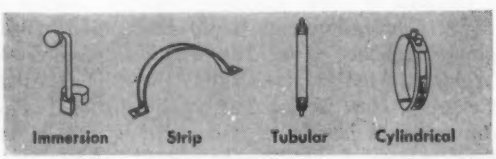
American Management Association. 29th National Packaging Exposition to be held at Convention Hall, Atlantic City, N. J. The National Packaging Conference also will be held at Convention Hall, April 4-6. Further information is available from AMA headquarters, 1515 Broadway, New York 36, N. Y.

April 4-7—

Nuclear Congress to be held in

Watlow's FIREROD combines in one unit the best of all those factors most often sought in an electric cartridge unit: it's the *HOTTEST* heater going (gives you 5 times more heat than any standard unit, yet offers an amazing *heat range* up to 1500°F and higher) . . . the *LONGEST LASTING* cartridge operating at *any* temperature (will out-live, out-perform 5 to 10 ordinary heating units) . . . and the most *DESIGN-WISE* cartridge available today (the *same* heat you'd get in a standard unit, in 1/5 the space).

So . . . whether you're looking for high concentration of heat or longer-lasting cartridge heaters – you'll want to learn more about the FIREROD. WRITE for FIREROD BULLETIN #367.



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the New York Coliseum, consists of the 6th Nuclear Engineering and Science Conference, the 8th NICB Atomic Energy in Industry Conference, and the 6th International Atomic Exposition. Congress is sponsored by 28 engineering, scientific, management, and technical organizations. Further information is available from 1960 Nuclear Congress, 33 W. 39th St., New York 18, N. Y.

April 5-8—

Society of Automotive Engineers Inc. National Aeronautic Meeting (including production forum and engineering display) to be held at the Hotel Commodore, New York. Further information can be obtained from society headquarters, 485 Lexington Ave., New York 17, N. Y.

April 18-19—

Third Annual Conference on Automatic Techniques to be held at the Cleveland-Sheraton Hotel, Cleveland. Additional information is available from conference publicity chairman, Room 530, 1213 W. Third St., Cleveland 13, Ohio.

April 21-28—

American Society of Tool Engineers. Tool Show to be held in the Artillery Armory, Detroit. Further information can be obtained from ASTE headquarters, 10700 Puritan Ave., Detroit 38, Mich.

April 25-29—

American Welding Society. 41st Annual Convention and Welding Exposition to be held in Los Angeles. Technical sessions will be at the Biltmore Hotel; the show, at the Great Western Exhibit Center, April 26-28. Further information is available from AWS headquarters, 33 W. 39th St., New York 18, N. Y.

April 27-28—

National Conference on Space-Age Materials to be held at the Sheraton Gibson Hotel, Cincinnati. Sponsor is the Cincinnati Chapter of the American Society for Metals. Further information can be obtained from ASM headquarters, Metals Park, Novelty, Ohio.

Circle 424 on Page 19

Symbol of Progress
In the World of Precision

ATLAS PRECISION PRODUCTS CO.

Specialists in the design and production of electro-mechanical assemblies and fine precision gears, differentials and components for use in computer, automation and guidance systems of industry and the Armed Services. Precision gears are Certified to meet A.G.M.A. specifications and stocked in pitches from 32 to 120. APPCO components are now in use in the nation's finest precision mechanisms.

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Wholly owned subsidiary producing power transmission products for all types of industries. Atlas Roller Chain, Flat-Veyor conveying chain, specialty chains, sprockets and flexible couplings have proved their outstanding performance value in every type of industry where power or motion is to be transmitted. Atlas Chain has pioneered many new innovations in the power transmission field and many new developments are now in the final test stage in their extensive research laboratories.

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PRUDENTIAL INDUSTRIES

Precision-eers For Industry

Circle 425 on Page 19

AN UNBEATABLE

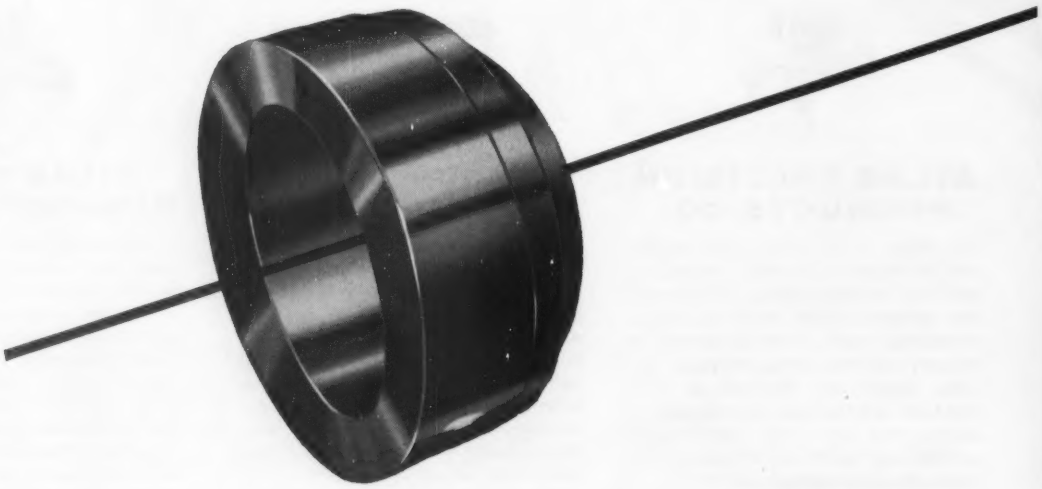
DURA-SEAL the engineered GRAPHITAR®... the versatile

(CARBON-GRAPHITE)

Dura-Seal, the best known and most widely used rotary mechanical shaft seal, has been designed and engineered in combination with a GRAPHITAR insert to meet nearly every industrial demand for sealing corrosive, volatile or abrasive fluids under a wide range of speeds, pressures and temperatures. GRAPHITAR's characteristics of corrosion resistance, chemical inertness, heat resistance and ability to operate in the presence of abrasive fluids make it the ideal engineering material in thousands of seal applications.

GRAPHITAR is being used successfully not only in seals, but in such diverse applications as packing rings, clutch release bearings, fluid coupling seals, piston rings, sump pump bearings and more recently, in the nuclear and rocket-missile field as moderators, reflectors, fuel jackets, vanes and motor linings.

GRAPHITAR can be utilized to advantage in almost every industry. Perhaps you can put GRAPHITAR . . . the versatile engineering material . . . to work for you.

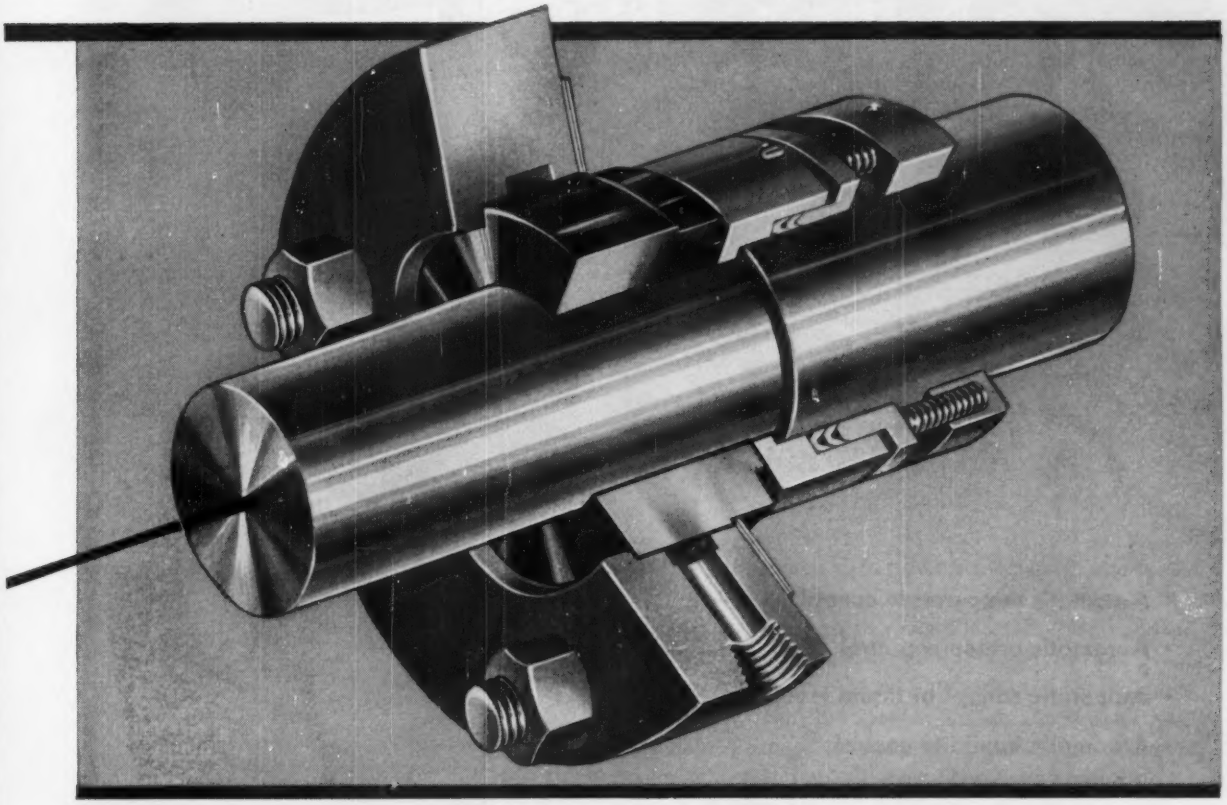


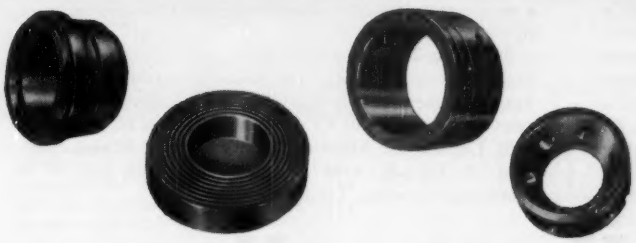
THE UNITED STATES

GRAPHITAR® CARBON-GRAPHITE • GRAMIX® POWDER METALLURGY • MEXICAN® GRAPHITE PRODUCTS • USG® BRUSHES

COMBINATION!

mechanical seal with engineering material





BULLETIN NO. 20 gives complete engineering facts on GRAPHITAR. Write for your free copy.

R-281-2

GRAPHITE COMPANY

DIVISION OF THE WICKES CORPORATION, SAGINAW 7, MICHIGAN

Circle 600 on Page 19

From Honeywell

A compact inexpensive controller

- **Automatic temperature control**
- **Automatic pressure control**
- **Automatic control of liquid level**
- **Automatic humidity control**

Exclusive Honeywell Versa-Tran replaces old fashioned mechanical control *at low cost.*

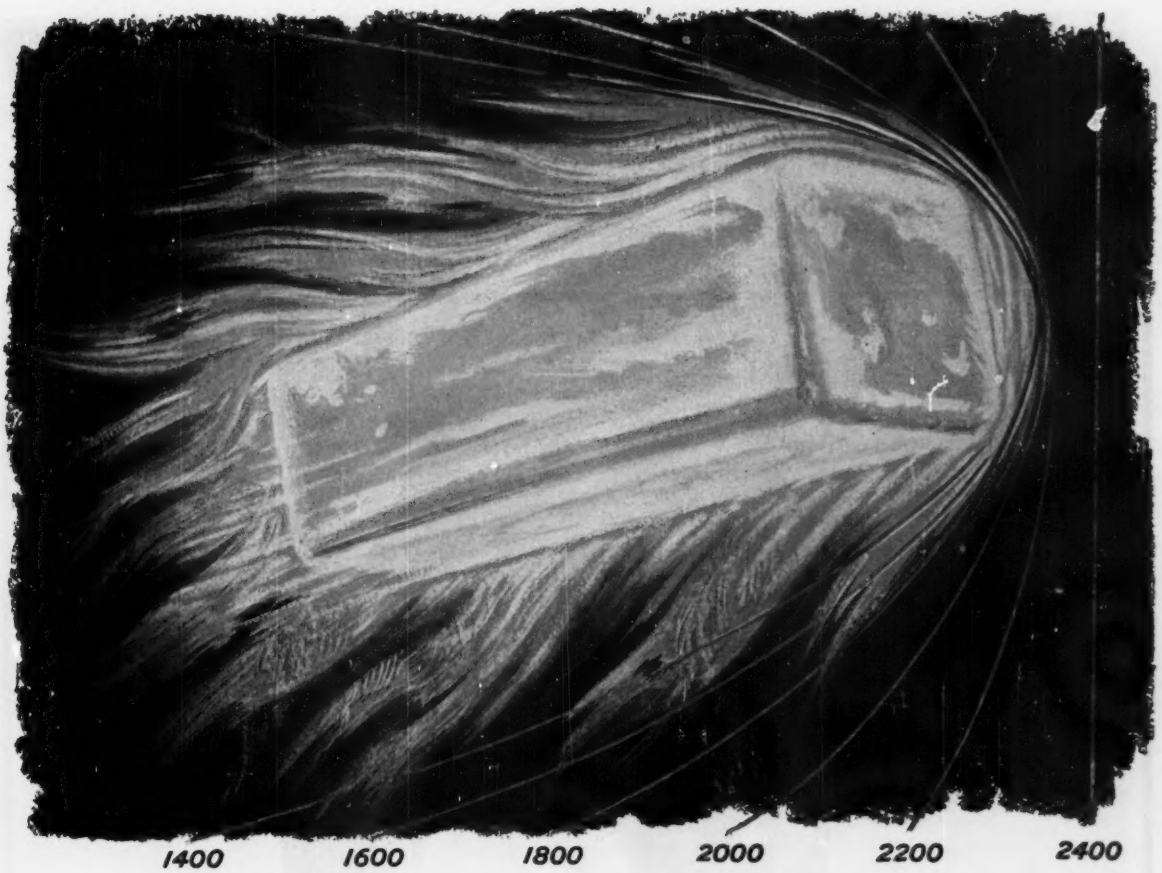
Now—a transistorized controller that's versatile enough to be used in many applications. Small, compact, with complete repeatability. No tubes, no warm up time, gives instant reaction. Works with sensors that can be thermistors, probes, resistance bulbs, pressure transducers or humidity elements. Can be used in such varied applications as packaging machines, injection molding machines, cooking vats, tire recapping, ice cube makers, and tanks, etc. Has a temperature control range from minus 60 degrees to plus 1400 degrees F.

The Versa-Tran is the result of traditionally superior Honeywell engineering. For information, call your nearest Honeywell office and our industrial control sales engineer will call. Or write: Minneapolis-Honeywell, Department MD-1-24, Minneapolis 8, Minnesota. In Canada, write: Honeywell Controls Ltd., Vanderhoof Avenue, Leaside, Toronto 17.

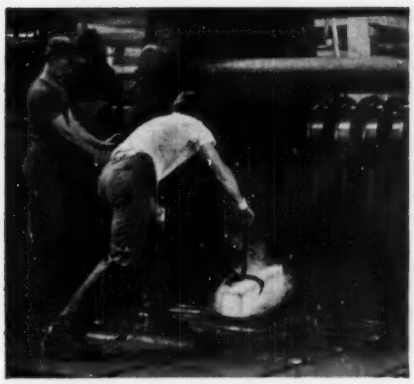
Honeywell

75th YEAR PIONEERING THE FUTURE

H HONEYWELL *First in Control* SINCE 1885



Bending the Heat Barrier



Specialized mill equipment is available at HAYNES STELLITE for rolling high-temperature alloys into a variety of shapes and sizes. Bar (above) is being produced on a 24-inch mill.

High strength plus resistance to oxidation, creep, thermal shock, and fatigue—are some of the properties that have helped to push the heat barrier back over the past 15 years. These are the properties found in HAYNES high-temperature alloys. Properties that make these alloys very useful in the 1000 to 2000+ deg. F. range.

Typical uses? The really hot spots in jet aircraft, ramjets, and missiles are some. Furnace components, heat-treating equipment, kiln liners are others. In fact, any part where long service life under severe high-temperature conditions is essential.

There are 12 HAYNES high-temperature alloys—available immediately in convenient forms that can be readily fabricated. For information on properties and prices, write for descriptive literature.

HAYNES ALLOYS

HAYNES STELLITE COMPANY
Division of Union Carbide Corporation
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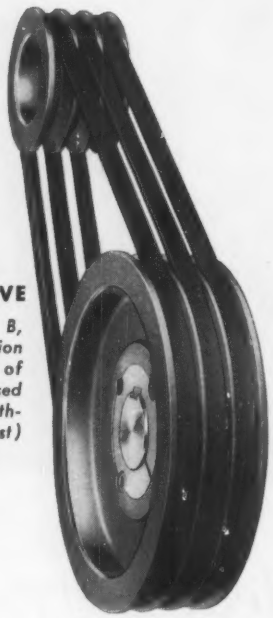
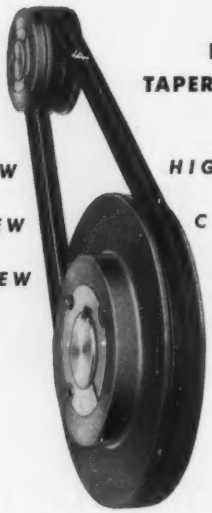
an entirely new line of V-Belt Drives.....

DODGE Dyna V



BIG-GROOVE TAPER-LOCK DRIVE

(— using standard A, B, C, D and E cross section belts, the hp ratings of which have been increased an average of 40% without any increase in cost)



DYNA-V TAPER-LOCK DRIVE

NEW HIGH CAPACITY

NEW COMPACTNESS

NEW SAVINGS IN COST

COMPARISON, ILLUSTRATED ABOVE — 3 HP, 1750 RPM, 2.41 TO 1 RATIO

	BELTS		SHEAVES			CENTER DISTANCE	HP	WEIGHT (LBS.)	COST	
	Number	Size	O.D. Driver	O.D. Driven	Width				Per hp	Per Drive
BIG-GROOVE TAPER-LOCK DRIVE	3	A42	4.15"	8.95"	2½"	12.3"	4.62	24.7	$5.62	$25.98
DYNA-V TAPER-LOCK DRIVE	2	3V400	3.35"	8.00"	1⅜"	10.8"	5.0	18.0	$4.50	$22.50
% SAVING *Savings vary with different sized drives*			19%	10%	56%	12%	+	27%	19.9%	13.4%

Dyna-V Drives are sensationally compact. They are capable of handling up to three times as much horsepower in a given space. Dyna-V opens vast new possibilities for better, more economical machine design. And, in most instances, *Dyna-V costs less!*

Narrower grooves, to match stronger, narrower Dyna-V Belts, greatly reduce the face width and the weight of Dyna-V Sheaves. Cost is lowered. Smaller diameter sheaves and shorter center distances multiply savings.

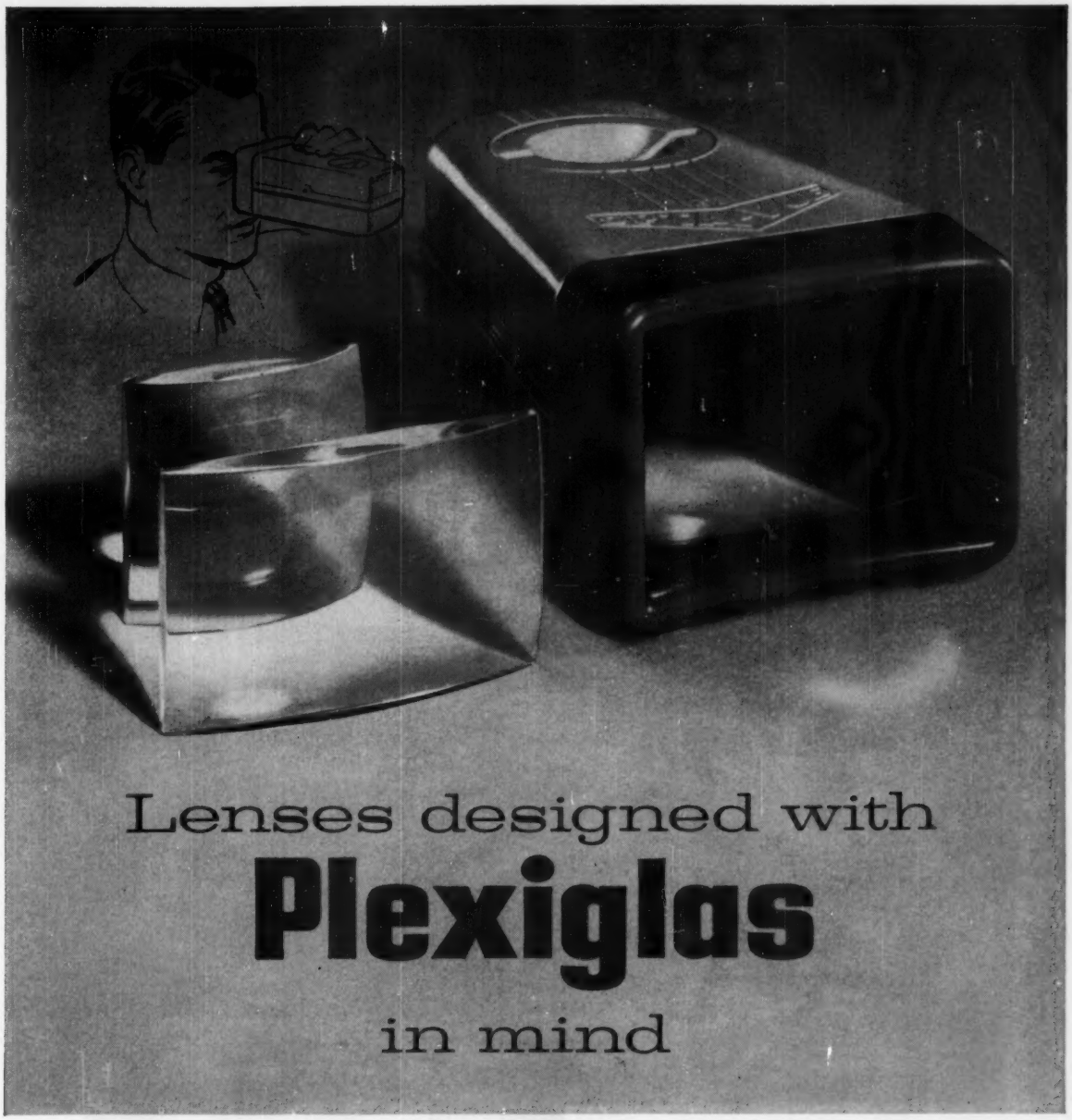
Dyna-V Sheaves decrease shaft overhang—increase bearing life. The new dimensional stability of Dyna-V Belts solves the problem of belt matching. Every belt carries its full share of the load.

Dyna-V Drives are available for capacities from 1 to 1500 hp. Ask your Dodge Distributor. Or write us for new Dyna-V Bulletin.

DODGE MANUFACTURING CORPORATION, 3300 Union St., Mishawaka, Indiana

DODGE of Mishawaka, Ind.

CALL THE TRANSMISSIONEER—your local Dodge Distributor. Factory trained by Dodge, he can give you valuable help on new, cost-saving methods. Look under "Dodge Transmissioneer" in the *white* pages of your telephone directory, or in the yellow pages under "Power Transmission Machinery".



Lenses designed with **Plexiglas** in mind

Problem. Design of a magnifying lens system for 35mm slide viewer*.

Requirements. Five-times enlargement of slide picture with clarity, sharpness and freedom from distortion. Lens system to be resistant to impact if viewer is dropped. Viewer to be priced within range of single-lens units.

Solution. Dual lens system, with lenses molded of optical grade PLEXIGLAS® acrylic plastic. Use of PLEXIGLAS resulted in lenses that give excellent performance and are highly resistant to breakage. Because lenses could be *molded* precisely to fine tolerances, considerable production cost savings were achieved through elimination of lengthy grinding and polishing operations required for glass lenses.

*"Opta-Vue", by Optics Mfg. Corp., Philadelphia 34, Pa.

Examples of fine quality molded parts made of PLEXIGLAS, *in many fields of use, are shown in our full color brochure, "*PLEXIGLAS *for Molded Parts". We will be pleased to send you a copy.*

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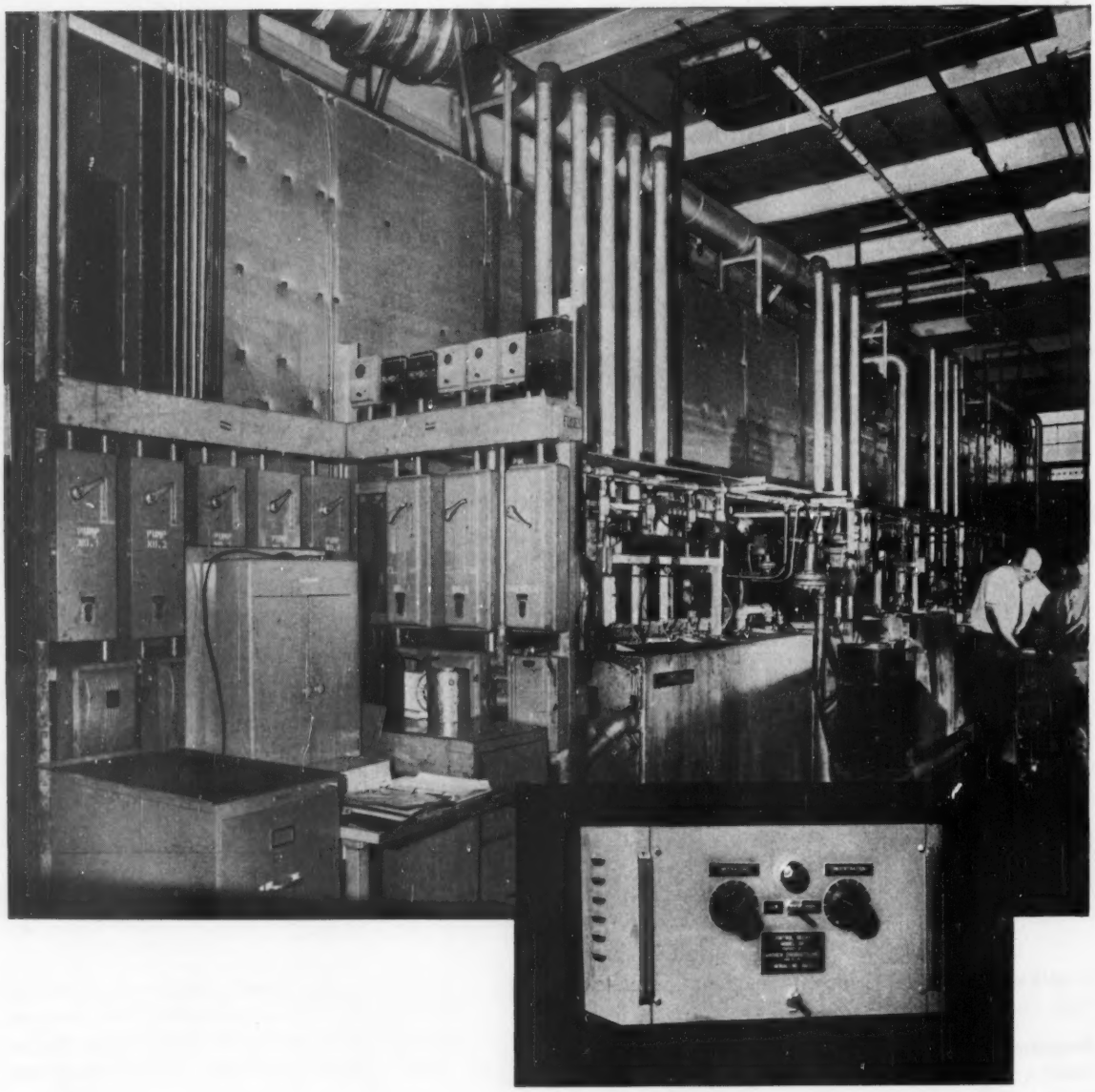
Crystal Glass & Plastics, Ltd., Toronto

Circle 429 on Page 19

AMCHEM AUTOMATION...a new



Many industry leaders in iron, steel and aluminum fabrication are already employing AMCHEM AUTOMATION to provide unmatched product protection and gratifying production savings to these products—aluminum siding, appliances, venetian blinds, fluorescent lighting fixtures, aluminum sign blanks, steel office furniture, automotive trim, aluminum windows and doors. Give your product the same protection, the same kind of savings — with AMCHEM AUTOMATION!

concept in chemical conversion coatings assures you constant, uniform quality, actually saves you money!

AMCHEM AUTOMATION means new standards of protection for your metal products with actual black-and-white savings in time and money you can't afford to ignore!

AMCHEM AUTOMATION takes the human element out of your conversion coating processing—replaces it with 100 percent electronic line control that virtually assures you of constant, uniform quality. Rejects due to faulty bath control plunge to new lows. Product assembly moves faster through inspection as AMCHEM AUTOMATION guards quality round-the-clock!

AMCHEM AUTOMATION releases quality control personnel to other duties, builds employee morale and pride in their work. AMCHEM AUTOMATION watch dogs chemical replenishment—bath is never overloaded or under strength. You reap big savings in time, labor and chemical costs!

AMCHEM AUTOMATION can be yours right now for metal pre-treatment and protection on a variety of fabricated products. Just say the word, we'll have an Amchem Automation Coordinator—a specialist in electronic line control—fill you in on all the time, money and labor saving details!

AMCHEM PRODUCTS, INC.

(Formerly American Chemical Paint Co.)

First in automated chemical conversion processing

AMBLER, PA. • Detroit, Mich. • St. Joseph, Mo. • Niles, Calif. • Windsor, Ont.

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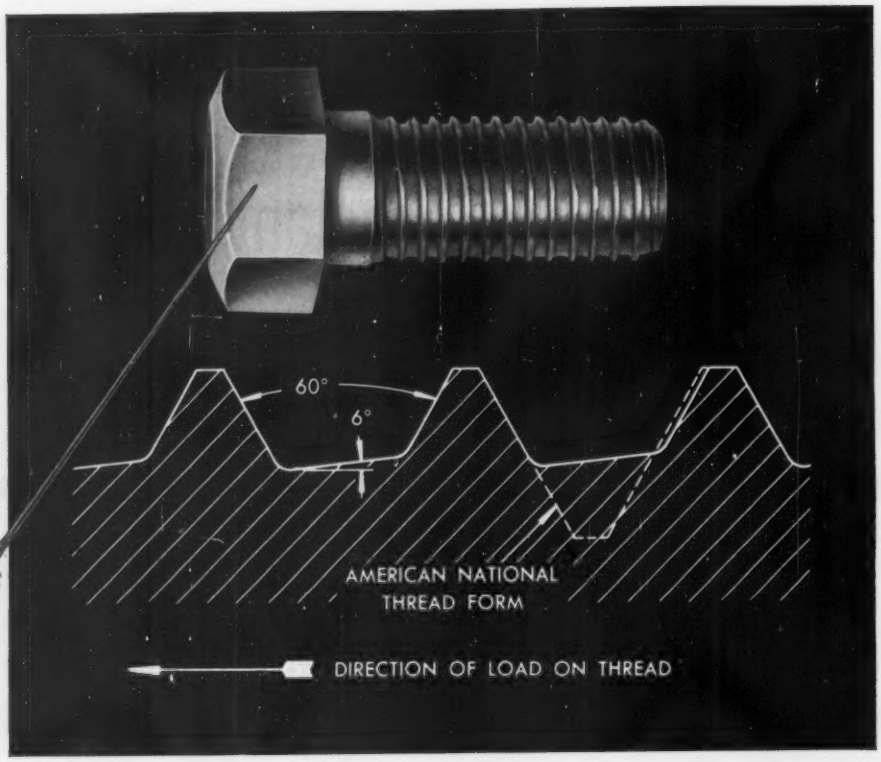
NAT'S quick facts about Fasteners...



Can **any** fastener actually **become tighter** in service?

WELL, HARDLY. NOT JUST *ANY* FASTENER...

But self-locking, extra-strength LOK-THRED® bolts, studs and screws *do*, and even after long service you can expect their breakaway removal torque to average about 70% higher than at installation.

Here's the reason. Just take a look at the LOK-THRED profile. Notice the extra-wide root? And its converging angle? It's held, strictly by design, to exactly 6 degrees.

Now, see what happens, as you drive any LOK-THRED fastener. It re-forms the metal of the receiving thread, squeezing out every void, and forming an intimate metal-to-metal contact. And each of the angled roots becomes a 6-degree tapered wedge, with the loading constantly pulling against it to make its anchorage even firmer.

That's why LOK-THRED fasteners actually *do* become tighter in service. They're self-sealing, too... fluids can't leak past them. And yet they're fully reusable... require no selective fits... can be used with ordinary tools.

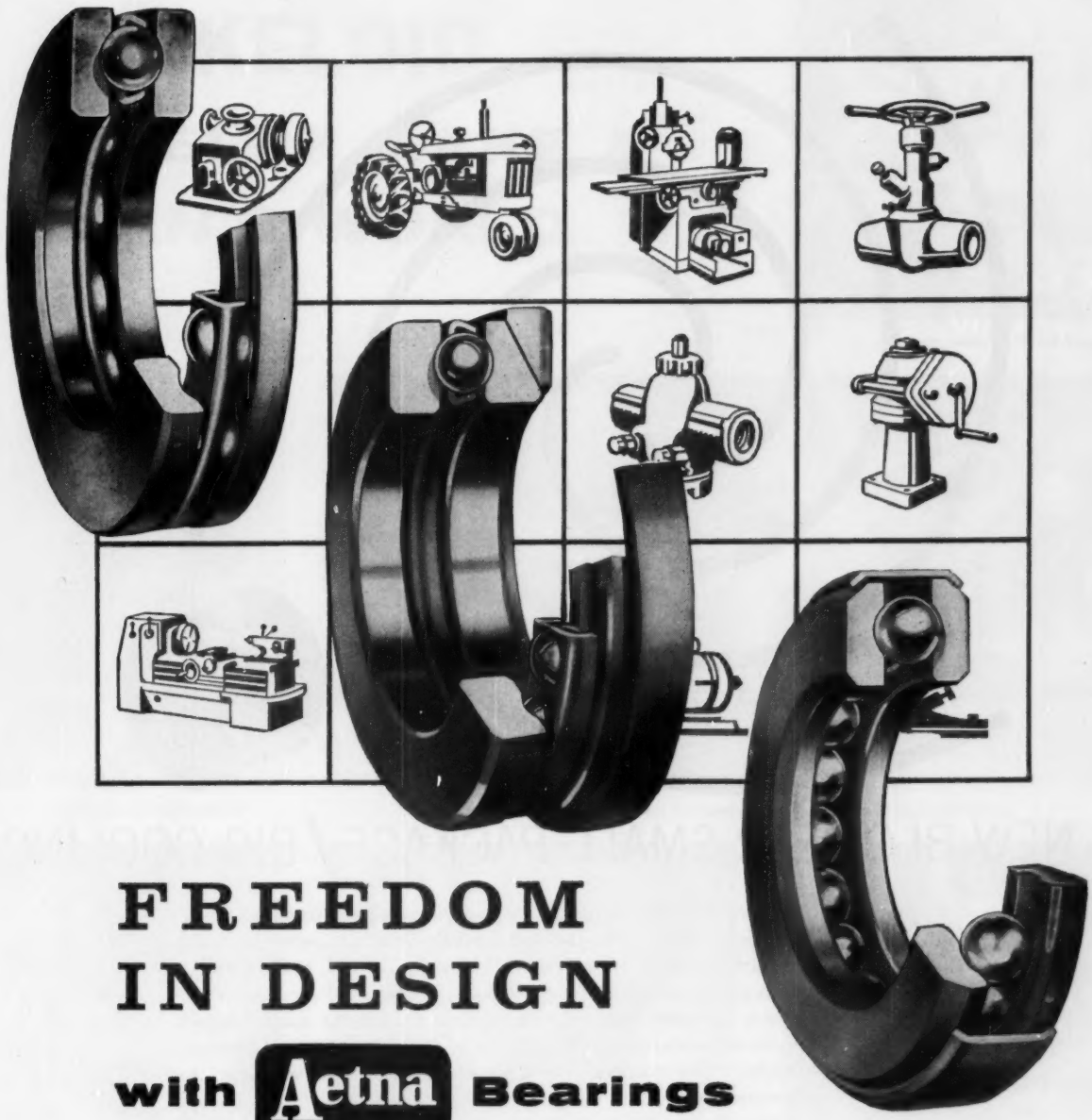
Take our word for it, there are plenty of reasons* why LOK-THRED is superior for many kinds of fastening... and we'll be glad to help you develop any applications to your own products.

*They're all given in National's LOK-THRED booklet, with plenty of supporting data. Write for your copy.

National PRODUCTS

The National Screw & Mfg. Company · Cleveland 4, Ohio

California Division, The National Screw & Mfg. Company • 3423 South Garfield Avenue, Los Angeles 22, California



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Designers have learned that they can depend upon Aetna original thinking and creative engineering to provide greater freedom of design in meeting their anti-friction problems.

In the solution of difficult problems, Aetna's specialized knowledge and experience—combined with fresh viewpoints, ingenuity and a sincere desire to serve—have produced practical combinations or arrangements of an unusual nature which enabled designers to produce better operating, more simplified equipment at lower manufacturing costs.

CALL UPON AETNA WHEN you have equipment in the design stage which presents special bearing problems. Our experienced, creative engineering department will gladly work with you to produce the special bearings or precision parts which meet your design requirements.

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ANTI-FRICTION SUPPLIERS TO LEADING ORIGINAL EQUIPMENT MANUFACTURERS SINCE 1916

Circle 432 on Page 19

NEW BLOWER : SMALL PACKAGE / BIG COOLING

For cooling an electronic hot box in a missile or airplane Globe Industries' new Type FC blower is the optimum combination of high performance and small size. Only 2 13/16" in diameter it can handle 100 cfm. of air against a back pressure equivalent to 3.5" of water, or up to 169 cfm of free air. Weight is 14 ounces, and units are designed to meet MIL specs. The unit pictured is powered by a 115 or 200 v.a.c., 400 cycles, 3-phase Globe type FC motor. Three mounting options are available. A smaller version will be announced soon.

If your "optimum" requirement is something more or less potent than the new Type FC, consider these facts: 1) Because Globe is the largest manufacturer of precision miniature motors, Globe engineers have the greatest possible access to standard as well as developmental motors to meet requirements exactly. 2) Globe's cooling specialists are expert in high-efficiency propeller design. 3) Globe's extensive blower and fan line may **already** contain what you need. Orders for one, ten, or 10,000 blowers are welcomed. Request Catalog B-1 for technical information about Type FC and other miniature cooling equipment. GLOBE INDUSTRIES, INC., 1784 Stanley Avenue, Dayton 4, Ohio. Telephone BAldwin 2-3741.

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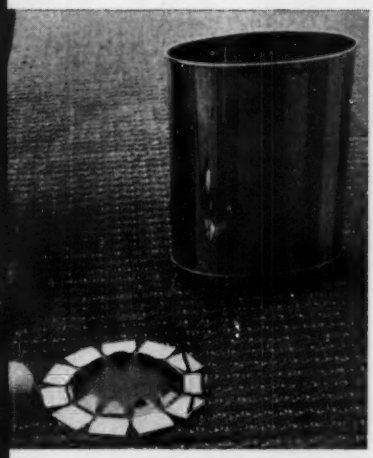
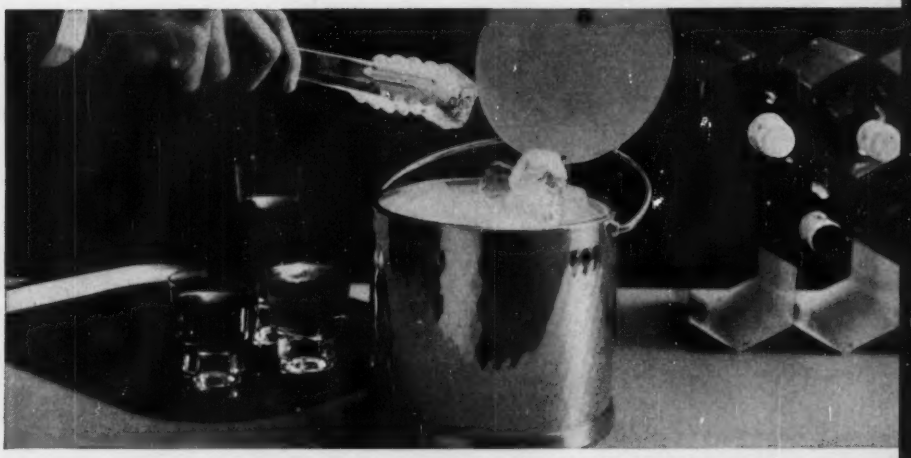
NICKELOID
HELPS MAKE A MAN'S WORLD

Fish lure, made of Nickel Brass.



ing disc (Chrome Steel) and waste basket.



Ice bucket, tongs, tray, and bottle holder—all made of Nickeloid Metals.

ir brush, made of Red Goldbond Steel.

Torpedo Level. The metal is Nickel Zinc.

Desk accessories, all made of Nickeloid Metals.

Whenever a man is at work, at home, or at play—his world is brightened by the utility and functional features of Nickeloid pre-plated metals. These durable, brilliant, and economical metals have been designed into so many articles for men because of their triple advantages: appearance plus basic production economy plus a finish that can "take it" as few other finishes can. Look about you . . . your desk, your home, your recreation room . . . note the many parts made of bright metals. Many of these, whether Chromium, Nickel, Brass or Copper, are quite likely to be fabricated from a Nickeloid Metal. Nickeloid Metals are available in sheets, coils, and strips—bright or satin—and in a beautiful range of stripes, patterns, crimps and textures. Write us for free Introductory Kit, which gives full information.

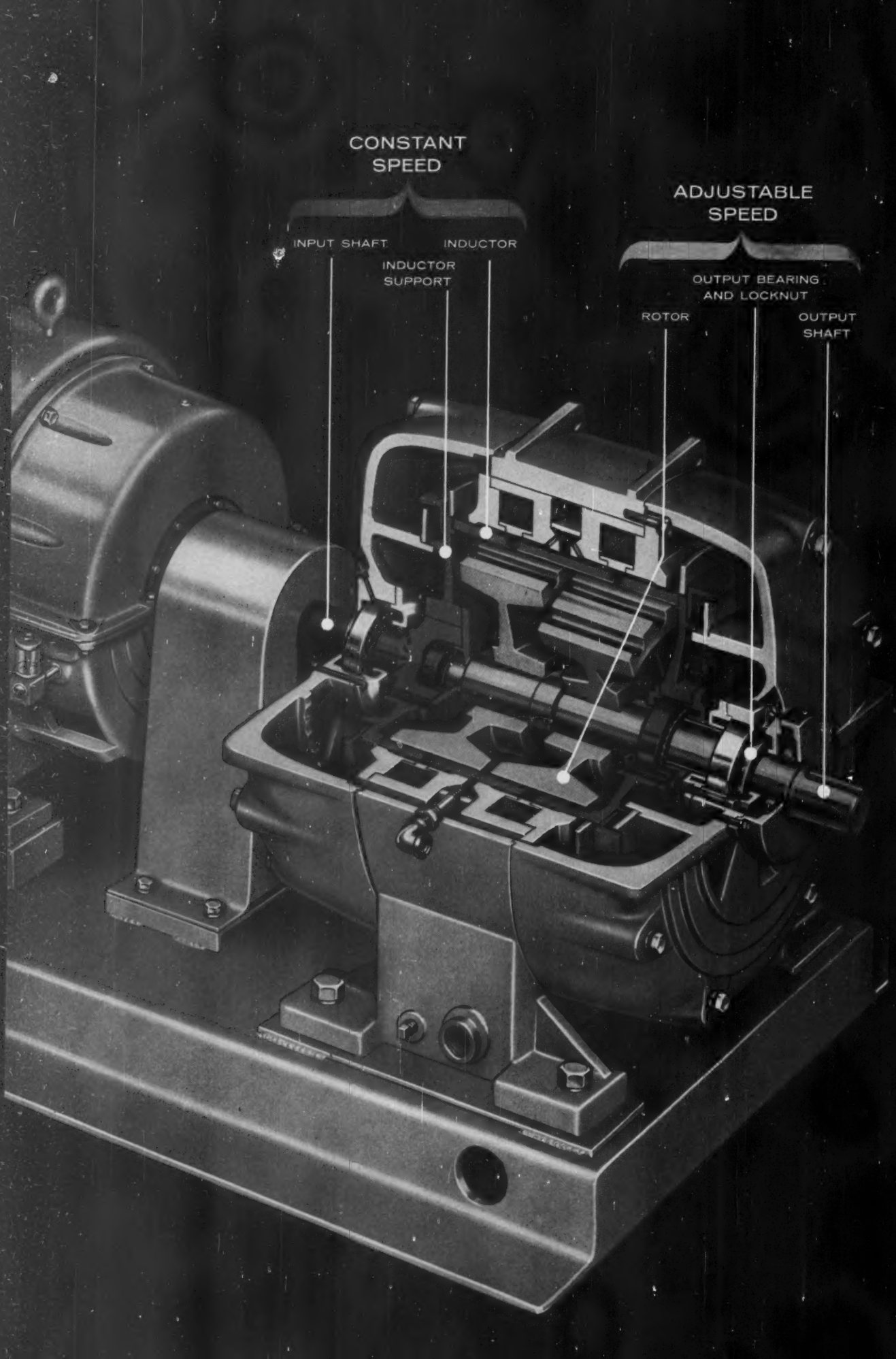
Sales offices in principal cities

NICKELOID METALS SINCE 1896 N M

Circle 452 on Page 19

AMERICAN NICKELOID COMPANY, PERU 8, ILLINOIS

PLANTS: PERU, ILL. AND WALNUTPORT, PA.


CONSTANT SPEED
ADJUSTABLE SPEED
INPUT SHAFT
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ROTOR
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Just a few of many application possibilities:

Test stands

Adjustable-frequency sets

Paper-machine drives, line shaft, sectional, or helper

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Another new product from Louis Allis

The new Louis Allis MAGNETIC DRIVE

A compact, precise adjustable speed drive up to 2000 hp!

If you use adjustable speed drives up to 2000 hp, you ought to know about the special features available in the *all-new* Louis Allis Magnetic Drive. Based on a liquid-cooled magnetic coupling design, this outstanding drive offers you the finest in precise regulation, compactness, and design flexibility.

A unique annular cooling manifold distributes the coolant over the outer surface of the inductor drum to provide an effective heat transfer. "Water drag" is eliminated, since there is *no* liquid in the air gap between the constant speed and adjustable speed members.

This new cooling principle eliminates "flooding" the Magnetic Drive and forcing of water into the bearings. And you'll never find condensation in the bearings, because the annular manifold design permits a planned flow of air through the drive at all times. This reduces bearing temperature and carries away any condensation which might occur as the unit cools off after use.

The design also incorporates stationary field construction, thus eliminating slip rings. All bearings can be easily lubricated without disassembly, and grease chambers provide ample grease reservoirs.

Other features include field coils and lead connections encapsulated in a special chemical and heat-resistant polyester — simplified construction for easy inspection and servicing — and versatile design for simple relocation of cooling inlet, conduit box, discharge, etc., regardless of direction of rotation.

If your plans call for adjustable speed drives — specify Louis Allis Adjustable Speed Magnetic Drive. For a complete description of these new drives, write for Bulletin 3650 — now available at your Louis Allis District Office or from The Louis Allis Co., 459 East Stewart Street, Milwaukee 1, Wisconsin.

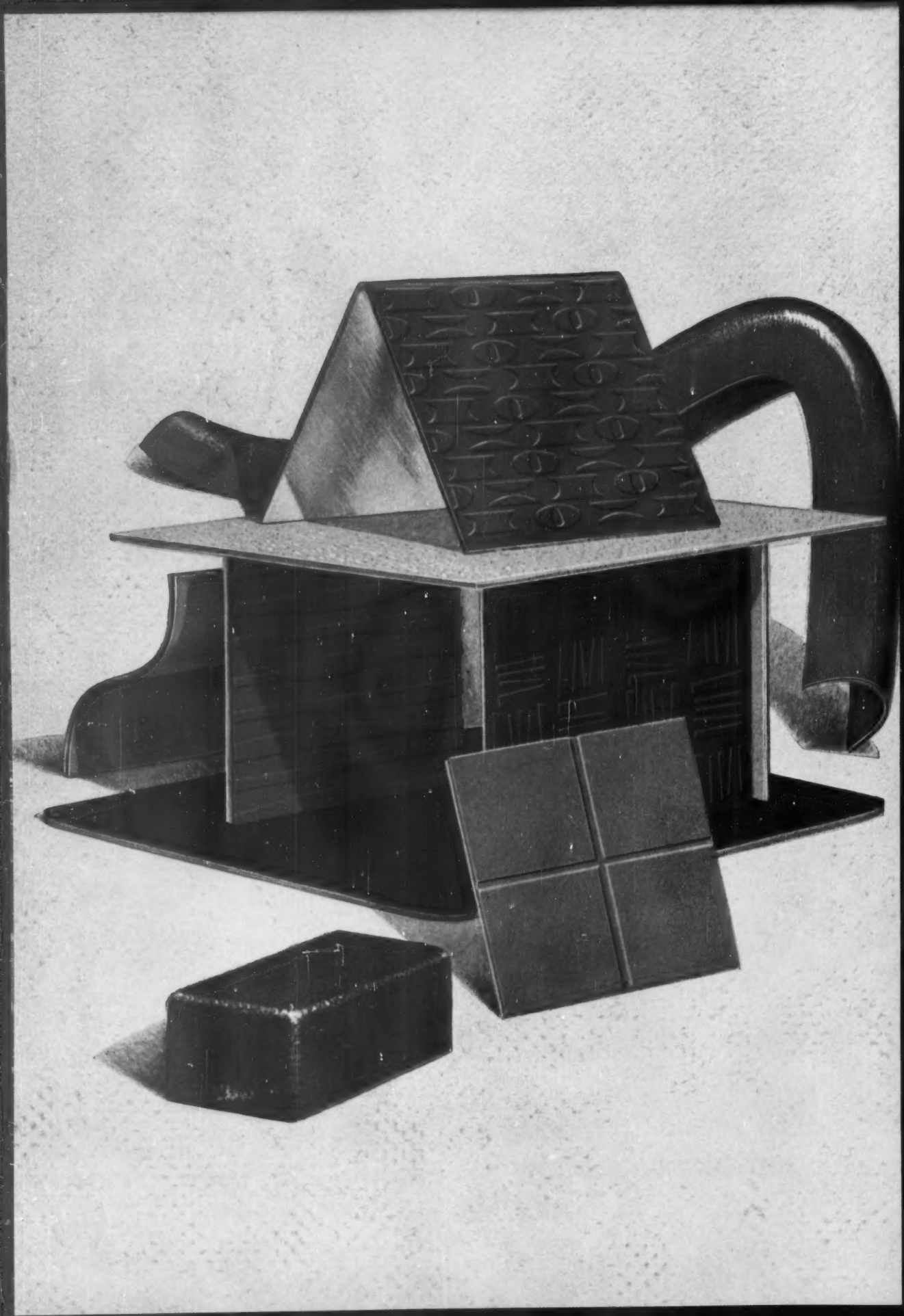
Two-field construction shown. Also built in one, three, or four-field construction with or without magnetic brakes. Simply specify your hp and speed requirements and Louis Allis will tailor the drive to your need.

MANUFACTURER OF ELECTRIC MOTORS AND ADJUSTABLE SPEED DRIVES

LOUIS ALLIS

Circle 434 on Page 19

ASD-132



The strength of metal, the decorative beauty and protection of plastics . . .

Vinyl-on-Metal is a marriage of materials that creates new dimensions in form, color, and texture . . . presenting new combinations of properties that can improve existing products or inspire new ones. Both tough and attractive, it is low in cost, easy to fabricate. Vinyl-on-Metal is already being successfully used for TV cabinets, airplane and automobile interiors, luggage, typewriter cases, radio sets, card tables and chairs, interior and exterior wall partitions.

Vinyl-on-Metal offers

COLUR: a wide range of colors, all fast with minimum fading

FINISH: thick, resilient and cushioned; thin, hard and smooth; or highly decorative textures; glossy, dull, or pattern embossed

ABRASION RESISTANCE: mar and scratch resistant, long wearing

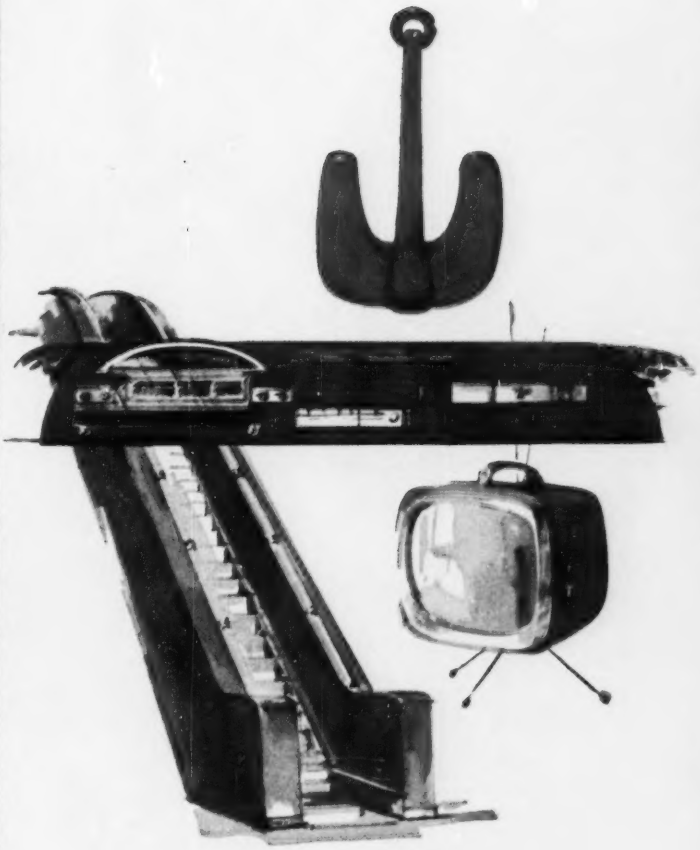
CHEMICAL RESISTANCE: resistant to acid corrosion, alkali attack, oxidation

MOISTURE RESISTANCE: resistant to water, washable with soap and water

WEATHER RESISTANCE: resistant to prolonged exposure to industrial atmosphere and accelerated weathering tests

EASE OF FABRICATION: can be formed, stamped, bent, punched, even welded into major components, eliminating almost all post-forming finishing

For handy reference booklet on Vinyl-on-Metal, write to Monsanto Chemical Company, Plastics Division, Room 1400, Springfield 2, Massachusetts.



MONSANTO INITIATOR IN PLASTICS

Monsanto

Monsanto Opalon® and Ultron® vinyls are the basic materials for superior vinyl finishes on metal, wood, paper, and glass.

Circle 435 on Page 19

New Super-Roadpacker is world's highest capacity vibratory compactor. Shown in operation on Ohio Interstate Route 1, it uses two 15-foot rows of vibrating shoes to compact roadbuilding materials at variable speeds best suited to the job.

vibration/shock/noise control for construction colossus

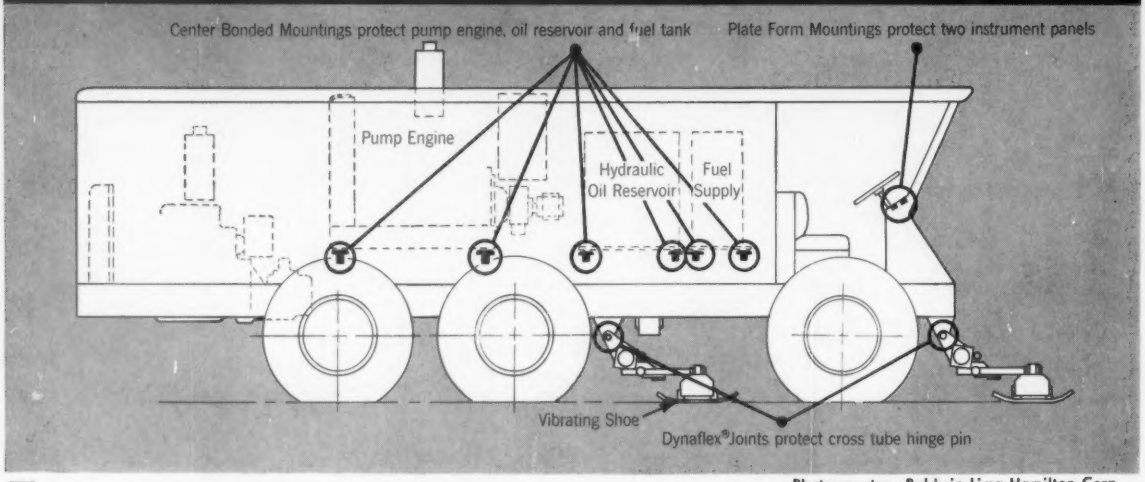

Center Bonded Mountings protect pump engine, oil reservoir and fuel tank
Plate Form Mountings protect two instrument panels
Pump Engine
Hydraulic Oil Reservoir
Fuel Supply
Vibrating Shoe
Dynaflex® Joints protect cross tube hinge pin

Photo courtesy Baldwin-Lima-Hamilton Corp.

This roadbuilding giant compacts soils by delivering 2200 blows per minute through its 12 vibrating shoes. The resulting disturbances could seriously damage vital components of the Super-Roadpacker. But LORD Mountings and Joints with controlled flexibility prevent damage by isolating vibration, attenuating shock and reducing wear.

Once again the benefits of engineered protection against shock and vibration are realized through better performance, longer service life and less maintenance.

Designers of equipment exposed to harsh jolts, vibration, distortion or misalignment can upgrade product quality with LORD vibration/shock/noise control. Proved benefits result when you use LORD elastomeric units at critical points—engines, radiators, batteries, hoods, cabs, seats, instrument panels, fuel tanks, transfer cases, load equalizers, radius rods.

Utilize LORD capabilities to solve your problem. Contact your nearest LORD Field Office or the Home Office, Erie, Pa.

LORD®
BONDED RUBBER

FIELD ENGINEERING OFFICES

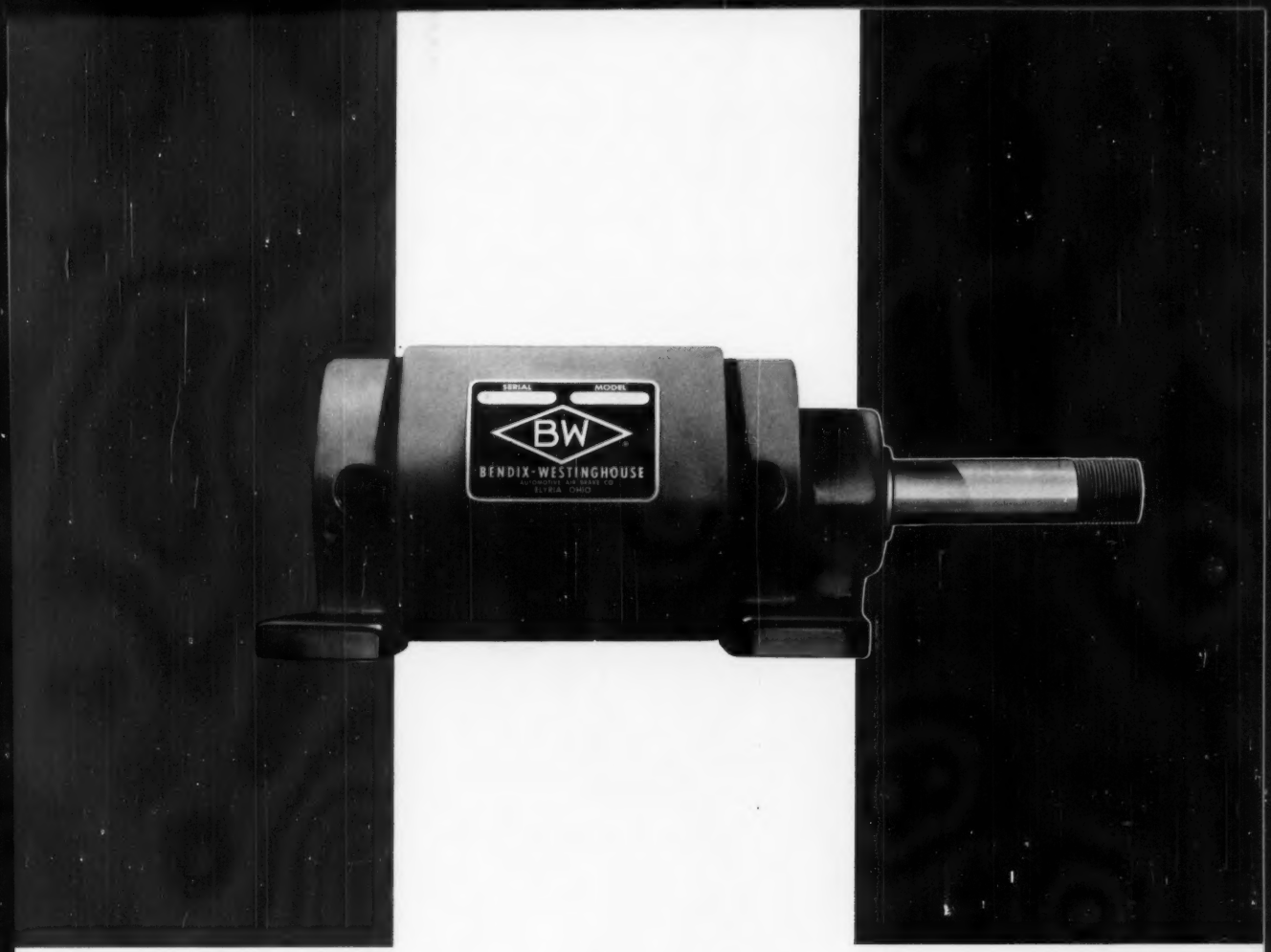
ATLANTA, GEORGIA - CEdar 7-9247
BOSTON, MASS. - HAncock 6-9135
CHICAGO, ILL. - Michigan 2-6010
DALLAS, TEXAS - RIverside 1-3392
DAYTON, OHIO - BAldwin 4-0351
DETROIT, MICH. - Diamond 1-4340
KANSAS CITY, MO. - WEstport 1-0138
LOS ANGELES, CAL. - HOllywood 4-7593
NEW YORK, N. Y. - Circle 7-3326
PHILADELPHIA, PA. - PEnnypacker 5-3559
SAN FRANCISCO, CAL. - EXbrook 7-6280
WINTER PARK, FLA. - Midway 7-5501

"In Canada—Railway & Power Engineering Corporation Limited"

LORD MANUFACTURING COMPANY • ERIE, PA.

Circle 436 on Page 19

Circle 437 on Page 19→



BENDIX-WESTINGHOUSE PISTON-TYPE AIR AND HYDRAULIC POWER CYLINDERS FOR EVERY APPLICATION!

Dependable performance, long life and easy maintenance are built-in features of the new Bendix-Westinghouse line of piston-type cylinders. Air or hydraulic, they combine the same high standards of quality as our well-known diaphragm-type cylinders. They're built to assure top, on-the-job performance at lowest cost. They are available in medium or heavy-duty models, standard or special purpose, for operating up to 200 psi with air, and 1800 psi with oil. Our standard line is readily available from a complete stock of machined parts. So whether your application calls for air or hydraulic power cylinders, Bendix-Westinghouse can answer your *every* requirement. Write us today for complete information.

CHECK THESE FEATURES:

• High efficiency assured through perfect alignment . . . low coefficient of friction! • Heavy-duty piston rod is high tensile . . . ground, polished and heavily chromed. Metal rod scraper cleans piston rod—protects rod, packing and bearing! • Spanner wrench hole simplified installation, protects piston rod! • Head and mount are integral castings! • Spring-compensated rod packings! • Packings are self-adjusting—wide bearing surfaces! • Mounting holes are spot-faced for full-cushioned cylinders! • Meet or exceed J. I. C. standards! • Heavy wall tubing, precision honed! • Large diameter piston rods for maximum columnar strength! • Long-life unitized cartridge-type rod bearing . . . simple replacement! • 360° rotation of pipe ports made possible by use of key-type locking ring . . . rapid removal of head! • Disassembly time minimized by relieved locking ring grooves! • "O" ring seal between head and cylinder wall eliminates leaks! • Cast-iron piston rings . . . optional!

Bendix-Westinghouse

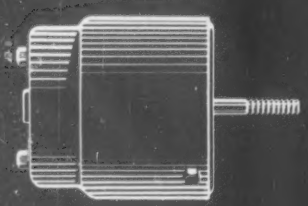
BW

INDUSTRIAL PRODUCTS

Bendix-Westinghouse Automotive Air Brake Company, Elyria, Ohio

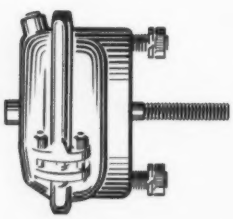
ROTOCHAMBERS

Frictionless. Leakproof. Neoprene diaphragm has a rolling action and exceptionally long life. Chrome molybdenum steel push rod. Available nine sizes delivering from 900 to 5000 pounds force at 100 psi air pressure.



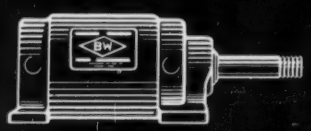
ROBOTAIR CHAMBERS

Small over-all diameter. No lubrication or filtering required. High grade steel stamping. Rubber diaphragm has flexing action. Leakproof. Available nine sizes delivering from 300 to 3600 pounds force at 100 psi air pressure.



POWER CYLINDERS

Piston-type air and hydraulic. Heavy wall steel tubing, precision honed. Head and mount are integral castings. Perfect alignment assures high efficiency. High-tensile, heavily chromed rod with metal rod scraper. Available in all mountings and sizes.



LOOK TO BENDIX-WESTINGHOUSE FOR A COMPLETE LINE OF INDUSTRIAL POWER CONTROLS

Diaphragm-type Air Cylinders • Piston-type Air and Hydraulic Cylinders

Now, whatever your industrial control application, Bendix-Westinghouse has a complete line of power cylinders to meet your *every* requirement. All are backed by the solid guarantee of precision, dependability and long life that you have come to associate with Bendix-Westinghouse. Our complete stock of machined parts assures prompt delivery. Should you require equipment for a special application, we can custom-build power cylinders tailored to your individual specifications. Call on Bendix-Westinghouse . . . our experience in specialized power cylinder problems is at your service. Write today for full information on how Bendix-Westinghouse industrial controls can make your job easier and save you money.

Bendix-Westinghouse

BW®

INDUSTRIAL PRODUCTS

Bendix-Westinghouse Automotive Air Brake Company, Elyria, Ohio

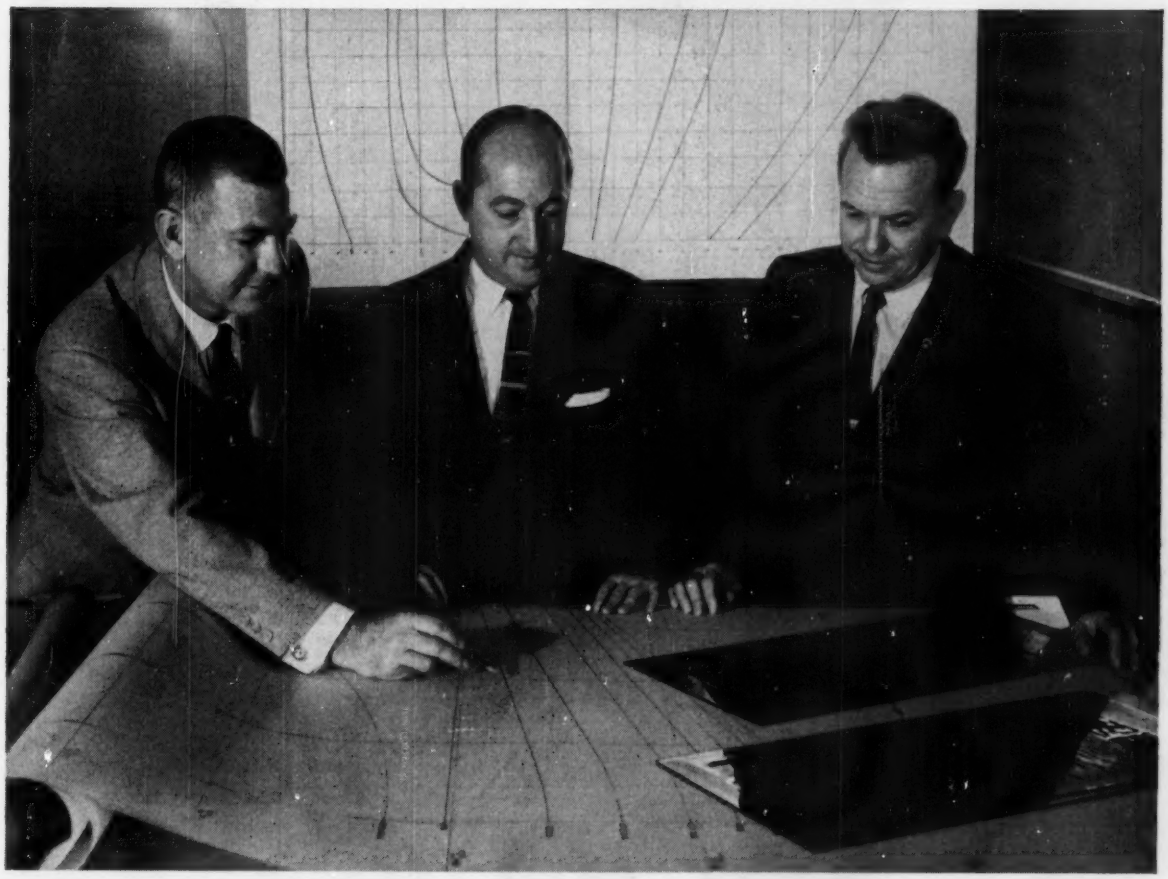
"CRONAFLEX® gives us the highest possible degree of stability in a reproduction film"

—North American Aviation, Inc., Los Angeles, California

North American Aviation, a leader in its field, uses CRONAFLEX *Engineering Reproduction Films for projection and direct positive printing. In addition to its incomparable stability,* CRONAFLEX *has other important advantages.*

*One North American spokesman puts it this way, "*CRONAFLEX *has excellent emulsion characteristics, too. Its speed and line density are remarkably uniform from batch to batch—an extremely important factor when you consider that we make upwards of 15,000 square feet of reproductions per month."*

CRONAFLEX *Films can cut time and costs in* your *plant, too. Ask your Du Pont Technical Representative for information or a demonstration. E. I. du Pont de Nemours & Co. (Inc.), Photo Products Department, Wilmington 98, Delaware. In Canada: Du Pont of Canada Limited, Toronto.*



North American Aviation's Los Angeles Division photographic experts, left to right: Clay Chapen, Supervisor of the X-ray Photo Template Lab; Buzz Holland, Manager of Photographic and Reproduction Department; Bob Mease, General Supervisor of Photographic Services, inspect a CRONAFLEX print to be used by engineers working on the B-70 triple-sonic intercontinental bomber developed by the company for the U. S. Air Force.

This advertisement was prepared exclusively by Phototypography.

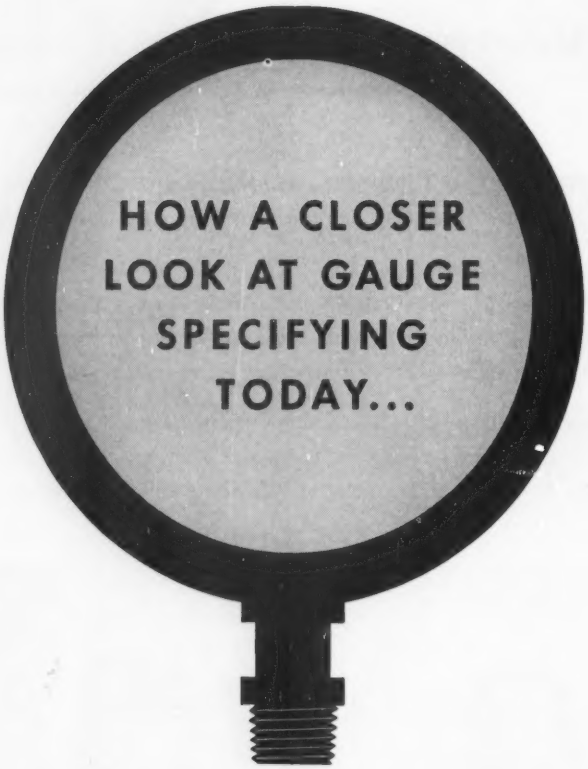
DU PONT

REG. U. S. PAT. OFF.

Better Things for Better Living . . . *through Chemistry*

←Circle 438 on Page 19

Circle 439 on Page 19



can keep you up on keeping gauge costs down

If you have a new product coming up, or design changes for a present product, and need *any* type of pressure gauge . . . you will get your gauge faster and save more by checking United States Gauge first. For these reasons:

First, USG has 50,000 standard gauges to draw on. Second, USG knows thousands of modifications possible with standard gauges to meet special design requirements more economically. Third, the men at USG know your competitive need to design better performance into equipment and deliver faster, while reducing costs.

Finally, at USG you will get exactly the gauge accuracy and performance you want for your purpose and price . . . up to and including the finest high-precision test gauges made.

Today, USG gauges are specified by 6 out of 10 original equipment manufacturers. For a closer look at dependable performance and lower costs in your next gauge need, call your USG distributor, listed in the Yellow Pages. Or write direct to United States Gauge.

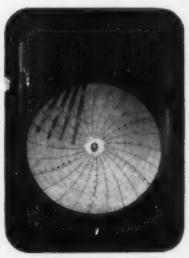
UNITED STATES GAUGE

Division of American Machine and Metals, Inc., Sellersville, Pennsylvania

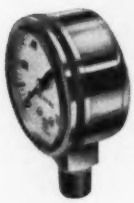
Find Your Nearest Distributor in The 'Yellow Pages'

Test Gauges

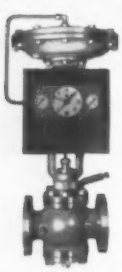
Pneumatic Receivers



Recorders and Recorder-Controllers



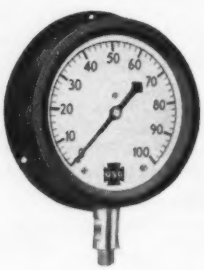
Drawn Case Gauges (Brass or Steel)



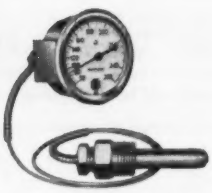
Indicating "Pilot" Controllers and Transmitters

Solfrunt® (Supergauge) with blow-out back

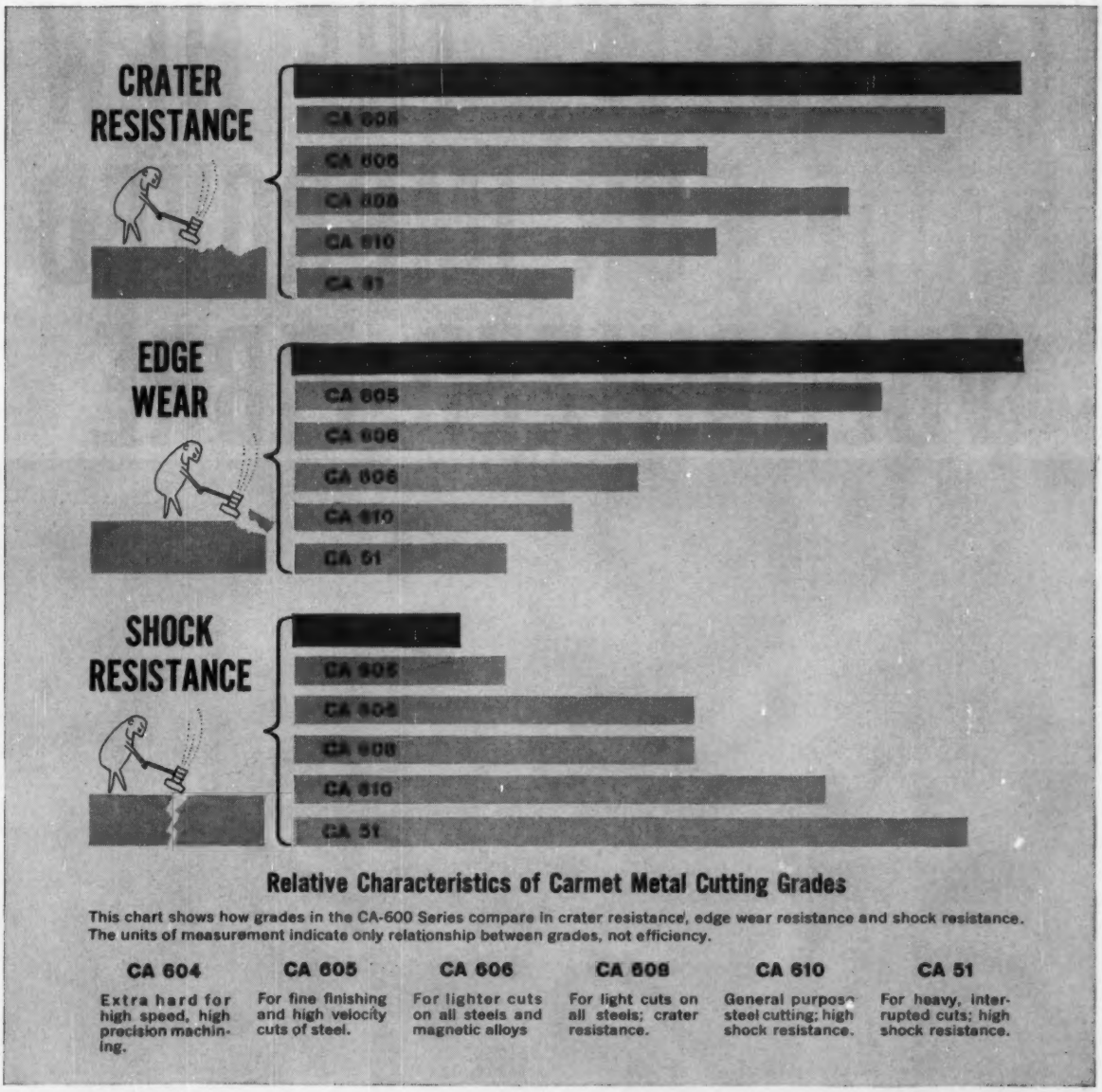
Supergauge® (A.S.A. Grade AA) Line



A-Line (A.S.A. Grade A) Gauges



Drawn Case Thermometers, too



Relative Characteristics of Carmet Metal Cutting Grades

This chart shows how grades in the CA-600 Series compare in crater resistance, edge wear resistance and shock resistance. The units of measurement indicate only relationship between grades, not efficiency.

CA 604	CA 605	CA 606	CA 608	CA 610	CA 51
Extra hard for high speed, high precision machining.	For fine finishing and high velocity cuts of steel.	For lighter cuts on all steels and magnetic alloys	For light cuts on all steels; crater resistance.	General purpose steel cutting; high shock resistance.	For heavy, interrupted cuts; high shock resistance.

HERE'S THE QUICK STORY ON THE NEW CARMET® CA604

Super-hard cemented carbide designed for today's high-speed, high-precision machining of steel

Product of Allegheny Ludlum research, CA604 is now added to Carmet's crater-resistant 600 series. It is an ultra-hard tungsten carbide with unusually high crater-resistance, wear life and high strength at elevated cutting temperatures. CA604 is an outstanding performer in the fast cutting ceramic areas, combining high velocity finishing with light to medium feeds.

CA604 is offered in Indexable Inserts and Blanks by your Carmet distributor. He carries Carmet standard tools, holders and Indexable Inserts in stock and assures prompt delivery. Call him for help in selecting the proper grades and styles for economical machining—or write *Allegheny Ludlum Steel Corporation, Carmet Division, Detroit 20, Michigan.*

218

Write for New-Revised CATALOG C-16-B
CARMET CEMENTED CARBIDES FOR INDUSTRY

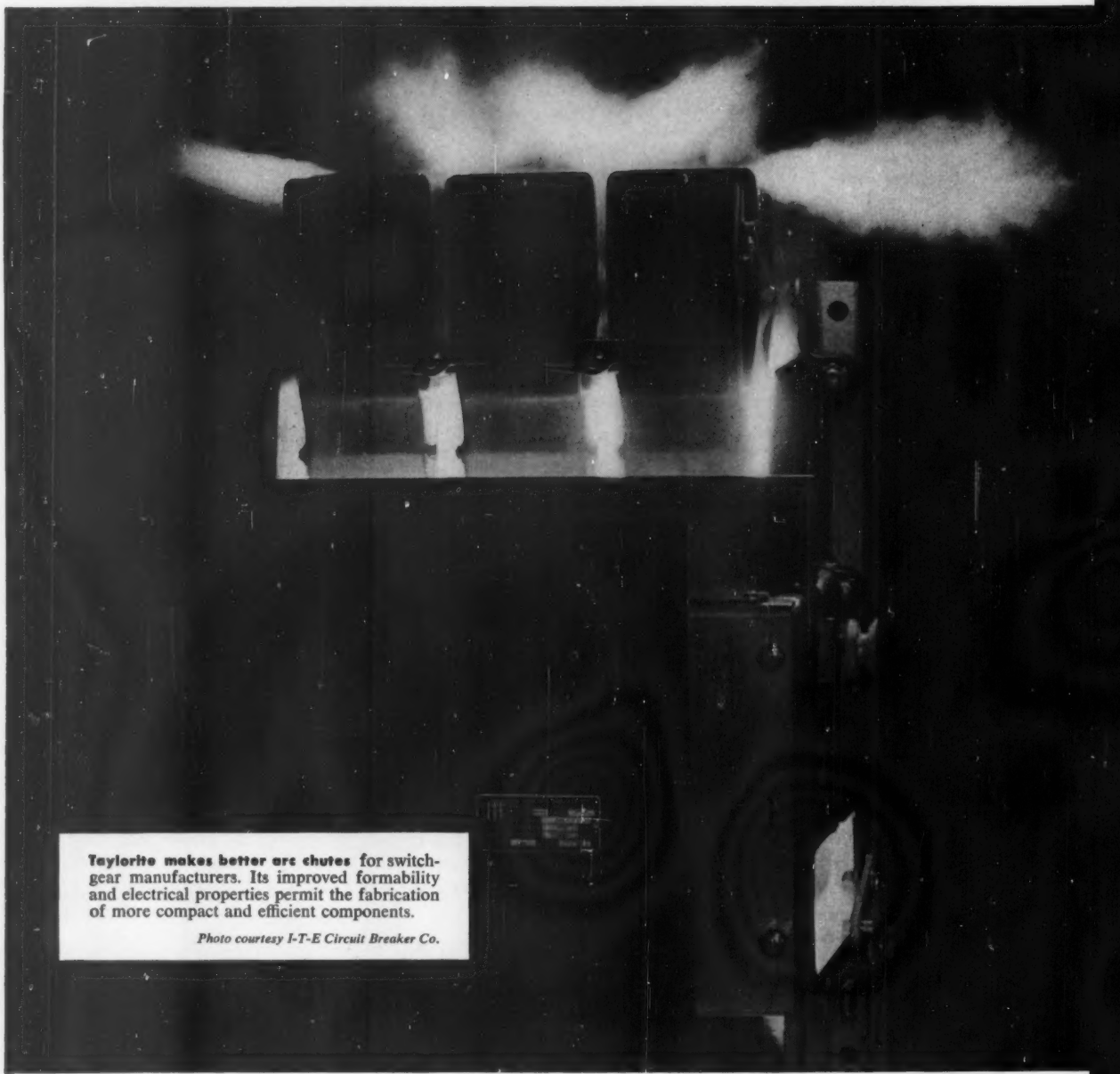
This 32-page book contains revised prices and complete specifications on Carmet's full line of cemented carbide tipped tools, blanks and holders. Speed and feed charts, grade comparisons and ordering information included.

ADDRESS DEPT. MD-25

CARMET

CEMENTED CARBIDE DIVISION OF
ALLEGHENY LUDLUM STEEL CORPORATION

"TAYLORITE"®--THE NEW NAME FOR IMPROVED VULCANIZED FIBRE



Taylorite makes better arc chutes for switchgear manufacturers. Its improved formability and electrical properties permit the fabrication of more compact and efficient components.

Photo courtesy I-T-E Circuit Breaker Co.

Our vulcanized fibre is so improved that we have given it a new name. Better electrical, physical and mechanical properties, and greater uniformity from lot to lot have made this workhorse material even more adaptable to a broad range of applications throughout industry.

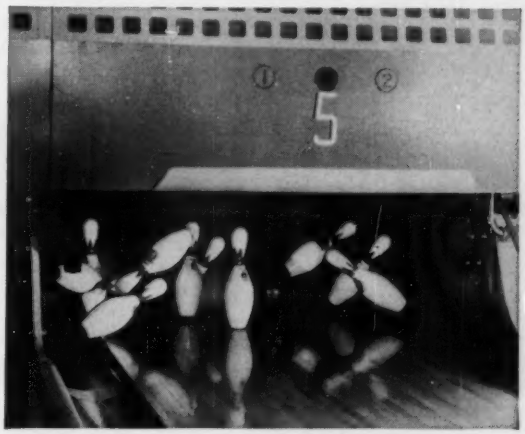
New Taylorite commercial grade, for example, has greater tensile strength, greater flexural strength, greater compressive strength, and greater dielectric strength than the older commercial grade. It is extensively used in the electrical industry. Its high impact resistance, good formability, toughness, and ability to be deep drawn make it an ideal material for 1001 industrial applications. Samples are available. Test them for yourself. Put them under tension, flex them, compress them, form them. You will find Taylorite passes your severest tests with flying colors. And remember, Taylor offers you complete design and engineering assistance.

Data Sheet 2-0 gives complete technical information—write for a copy and for samples today. Taylor Fibre Co., Norristown 47, Pa.

Taylor

LAMINATED PLASTICS VULCANIZED FIBRE

Taylorite offers new flexibility, ply adhesion, tear resistance, resilience and toughness to manufacturers of abrasive discs and drum sanders. Also uniform abrasive distribution.



Taylorite provides new impact resistance and toughness in many structural and mechanical applications. Typical of these is its use as kick back plates in bowling alleys.

Taylorite's improved electrical properties, impact resistance and high uniformity from lot to lot make it ideal for such vital applications as railroad track and switch insulating parts.

Gasket engineering

INTERNAL PRESSURE VS. EFFECTIVE SEALING

Internal pressure creates two forces which can cause leakage in a gasketed joint. Proper flange design and correct selection of gasket materials can overcome these forces.

E. M. SMOLEY,
Research Physicist
Armstrong Research and Development Center

The pressure of confined liquids or gases acts against a gasket in two ways, as shown in figure 1.

1. Hydrostatic end force. This is proportional to the internal pressure and

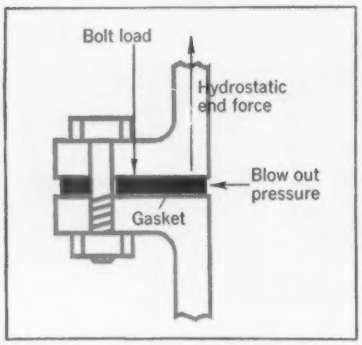


Figure 1. How internal pressure acts on a gasketed joint.

tends to move the flanges apart. As this occurs, the load on the gasket is reduced and leakage can result.

2. Blowout pressure. The sealed liquid or gas exerts direct pressure on

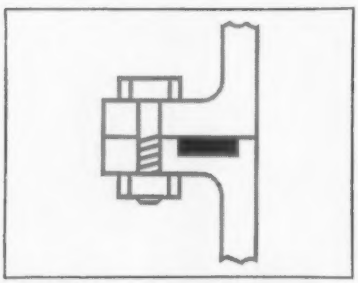


Figure 2. Flange design which confines gasket helps minimize blowout pressure.

the inside perimeter of the gasket. If this pressure is high enough, it will force the gasket out of the joint and leaks will occur.

These forces are usually associated with relatively high internal pressures. Studies at Armstrong Research and Development Center show, however, that pressures substantially less than 100 psi can cause leakage in some assemblies. (The Deflectometer shown in figure 3 is one tool used by Armstrong research engineers to measure flange deflection caused by internal pressure.)

Where internal pressures are involved, it is especially important to consider the joint as a unit. The flange design, the gasket material, and the temperature at the gasket line should all be considered in relation to each other.

The obvious first step is to be sure that flanges are sufficiently rigid to impose the required unit load on the gasket. The number of bolts, their size, their spacing, and their torque values are other factors related to flange loading which must be considered.

The second step is the evaluation of the gasket material to be used. High unit loads dictate the choice of a material that will not extrude or rupture under high pressures. This usually means a dense cellulose fiber or asbestos fiber material.

Several compositions suitable for service under high flange loads are available in the Armstrong Accopac line of beater-saturated gasket materials.

Where a compressible material such as cork-and-rubber is to be used, a flange design which confines the gasket,

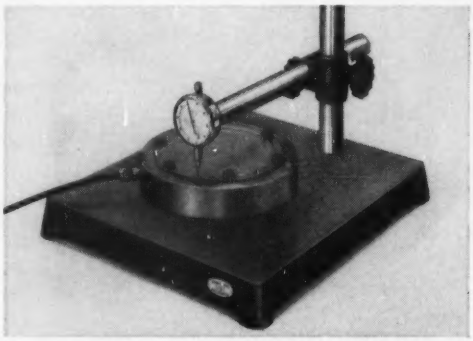


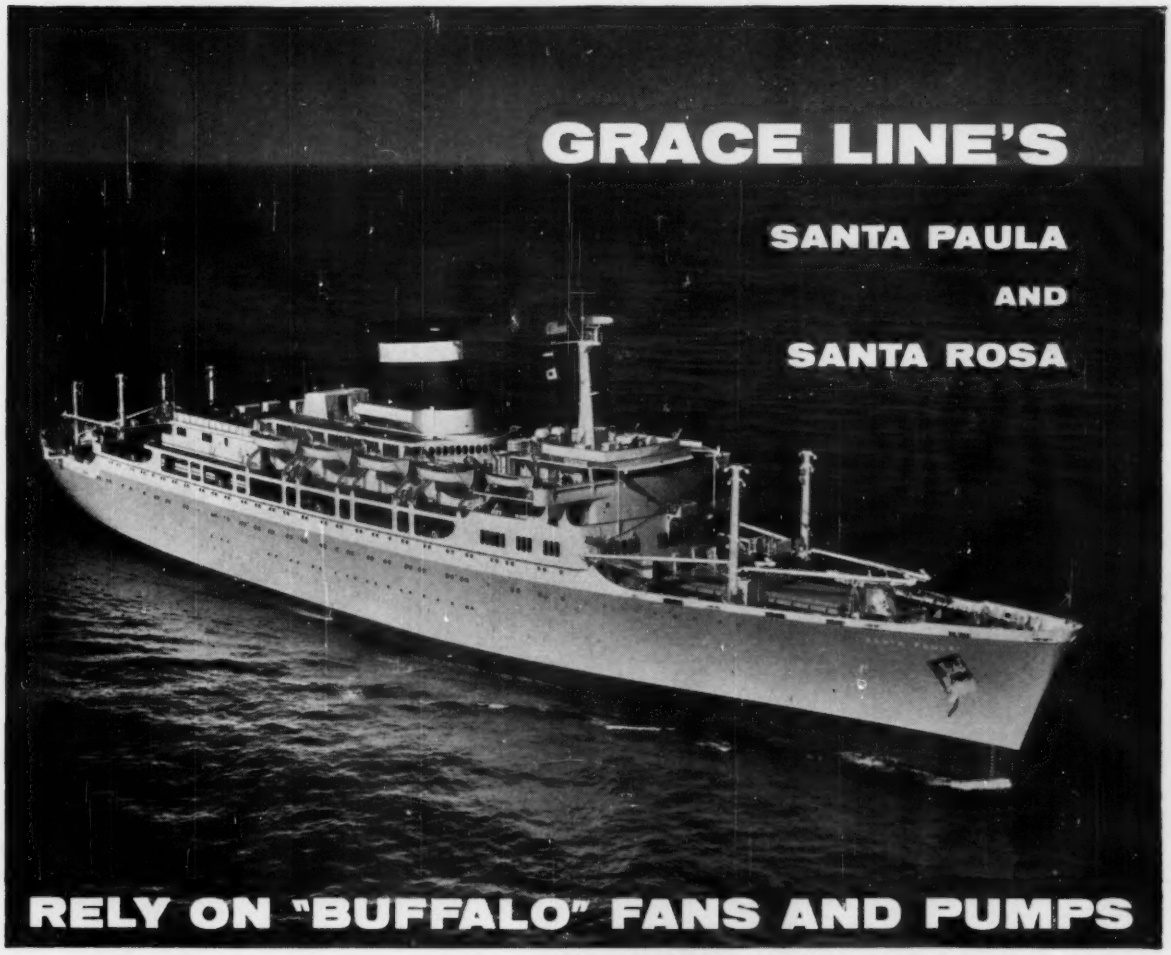
Figure 3. This Armstrong developed Deflectometer measures effect of 70 psi internal pressure in this stamped flange. Leak-producing deflections of .007" were detected at center point between bolts.

as in figure 2, will also help overcome blowout pressure.

A more complete discussion on the effect of internal pressure and other problems of gasket design, selection, and performance is included in the Armstrong Gasket Design Manual. Write today for your copy of this 32-page book. Address Armstrong Cork Company, Industrial Division, 7101 Imperial Ave., Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS

1860–1960 Beginning our second century of progress



The Santa Paula and her sister ship Santa Rosa of the Grace Line were constructed by Newport News Shipbuilding and Dry Dock Co.

The Grace Line's Santa Paula and her sister ship, the Santa Rosa sail on weekly schedules from New York to the Caribbean. The 300 passengers on each ship are treated to the best. Complete air conditioning; play deck with largest outdoor swimming pool afloat; club; staterooms, all outside with private bath; balcony suites with verandas overlooking the sea; everything to guarantee passenger rest and recreation. Ports of call are Curacao, NWI; La Guaira, Venezuela; Aruba; NWI; Kingston, Jamaica; Nassau, Bahamas; and Port Everglades, Florida.

Contributing to the successful operation of each ship are 74 "Buffalo" Centrifugal Fans; 55 "Buffalo" Axial Type Fans; and 21 "Buffalo" Pumps. Engineered to give maximum performance and quiet operation with minimum maintenance, "Buffalo" Fans and Pumps have been widely used for marine service for many years. For reliable performance on your important air and liquid handling jobs, on sea or land, insist on "Buffalo" "Q" Factor* Equipment.

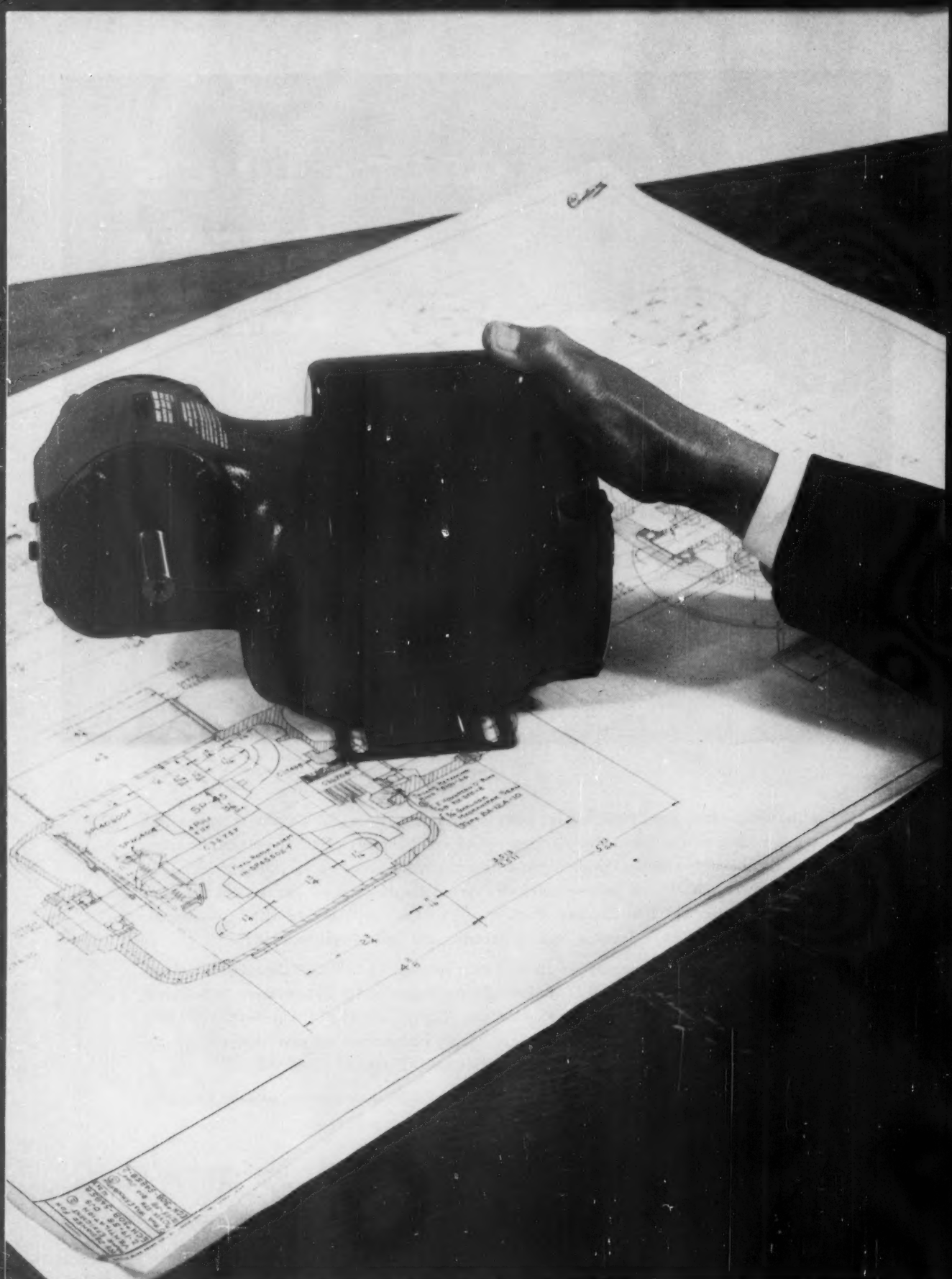
**The "Q" Factor — the built-in Quality which provides trouble-free satisfaction and long life.*

BUFFALO FORGE COMPANY Buffalo, New York

Buffalo Pumps Division, Buffalo, N. Y.

Canadian Blower & Forge Co., Ltd., Kitchener, Ont.

VENTILATING • AIR CLEANING • AIR TEMPERING • INDUCED DRAFT • EXHAUSTING • FORCED DRAFT • COOLING • HEATING • PRESSURE BLOWING



New Century Electric single-reduction, right-angle gear-motor is smaller, lighter and more versatile than ever.

New Century Electric Gearmotor

combines compactness with dependable power

Looking for a small gearmotor that is light and compact—yet able to handle heavy thrusts and the shock of sudden overloads? This new Century Electric single-reduction, right-angle shaft gearmotor may be the answer. Here are the facts:

Smaller and lighter. You can cut as much as 20 pounds from the weight of any product . . . in the ⅛ hp size, for example, this gearmotor weighs only 23 lbs. New insulating materials and new designs make more compact motors . . . new gearing and oil seal systems make gear housing smaller. Result: savings of about 50 percent in overall size.

Dependable power. Both motors and gearhead are built by Century Electric . . . means this gearmotor is backed from one source. Single-phase motors include capacitor start and split phase types. Polyphase motors are squirrel cage design.

Little or no service is needed because of features like:

High quality gear system—Worm gear is made of tough silicon bronze. Worm is made of hardened, high-grade steel. Both can withstand sudden shocks and overloads.

Dependable sealing system—No oil can get from gears into motor and cause costly shutdowns. A face-type seal with spring backing is used on the high speed shaft. A lip-type seal is used on the low speed shaft.

Output-shaft roller bearings—Roller bearings on output shaft provide reserve strength so motor can handle heavy radial and thrust loads and sudden shocks of overloads. Bearings are precisely aligned so worm and worm gear operate efficiently and quietly.

All-angle oiling—No matter at what angle motor is mounted, the worm or worm gear is always dipping in oil—so gears are always well lubricated. Means less wear and longer life.

Versatile mounting. You have complete freedom in mounting. Here's why. The gearhead can be assembled in four different positions in relation to the motor (the diagram below shows three of these positions) . . . shafts can extend from either or both sides of the gearhead . . . oiling and sealing systems make it possible to install gearmotor at any angle.

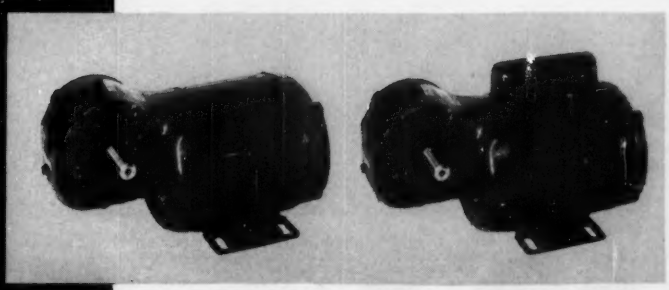
You can get more information from your nearest Century Sales Office or Authorized Distributor. Variations are available to fit specific design needs. For a copy of the new Century Electric Motor Application Guide, write for bulletin 270A.

CENTURY ELECTRIC COMPANY

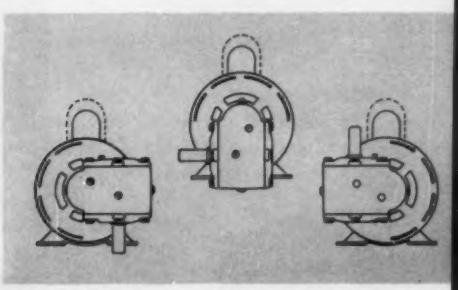
St. Louis 3, Missouri *Offices and Stock Points in Principal Cities*

Century

59-12

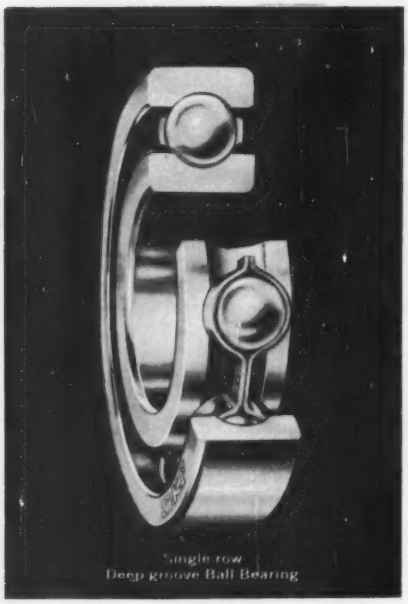


Both polyphase motors and single phase, capacitor start motors are available in the new Century Electric gearmotor.



Three of the four possible mounting positions of gearhead . . . shaft can be extended from opposite side in all cases.

Circle 444 on Page 19



Can a standard bearing offer you "more bearing" for your money?

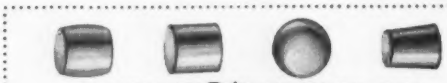
It can if it's made by SKF—because all SKF bearings, both ball and roller, offer special qualities at "production" bearing prices.

Take the single-row deep-groove ball bearing featured here, as an example. SKF designs and builds this type to sustain heavy radial load and thrust load in either direction. Furthermore, it is engineered to run smoothly and quietly at normal speeds with grease lubrication—and at high speeds with oil.

Yet this is a standard SKF ball bearing, mass-produced by automated production equipment at our plant at Altoona, Pa. You can quickly get this bearing in over 100 sizes, ranging from 5/8" to 15.748" O.D., and in a variety of seal, shield and snap-ring combinations.

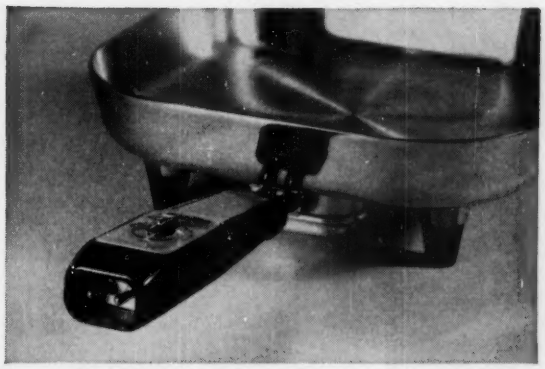
But why not find out what SKF offers in bearing quality, availability and economy? Just call the SKF branch office nearest you.

6001



Spherical, Cylindrical, Ball, Tyson Tapered and REED Miniature Bearings

EVERY TYPE—EVERY USE
SKF
INDUSTRIES, INC., PHILADELPHIA 32, PA.



1 The handle of this automatic fry pan is molded of phenolic to:
(a) stay cool *(b) fit small hands*
(c) insulate inner wiring

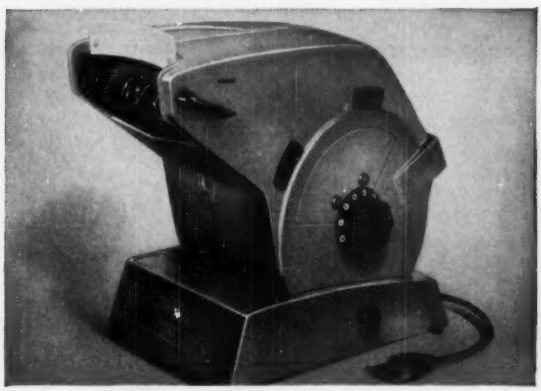
2 In 18 years, it's been re-coated with phenolic paints:
(a) 2 times *(b) 5 times*
(c) 9 times

Can you pass this test on Phenolic Plastics?

(You'll discover more of their potential as design materials)

3 This modern electronic circuit is *printed* on a base of:
(a) molded phenolic *(b) phenolic-impregnated paper laminate*
(c) phenolic-coated metal

4 These smoother-finished metal castings result from:
(a) phenolic-bonded shell molds *(b) phenolic-based coatings*
(c) phenolic-bonded grinding wheels



5 This device to test vision has a molded phenolic case that:
(a) cuts weight 50% *(b) needs 25% less tooling*
(c) requires no coating

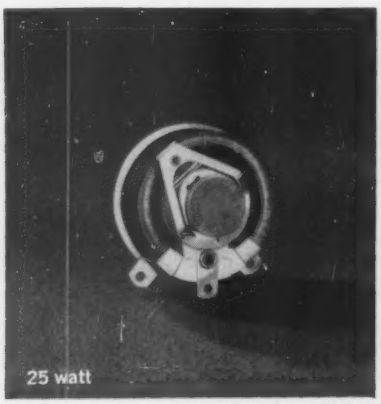
ANSWERS... *to design and production problems throughout industry are found in dependable BAKELITE phenolic plastics.*

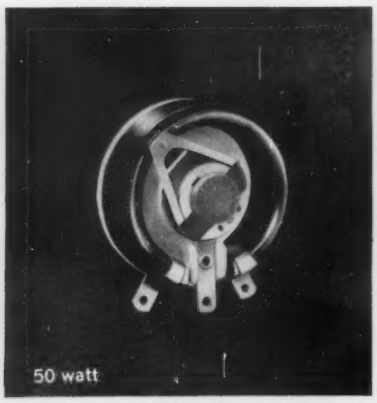
1. Check (a) and (c), and add durability.
2. (a) Twice—phenolic paints last 7 years on the San Francisco Bay Bridge.
3. (b) A laminate—machineable, chemically inert, and non-conductive.
4. (a) Lightweight shell molds that virtually eliminate machining.
5. Check (a), (b), and (c)—it saved all around.

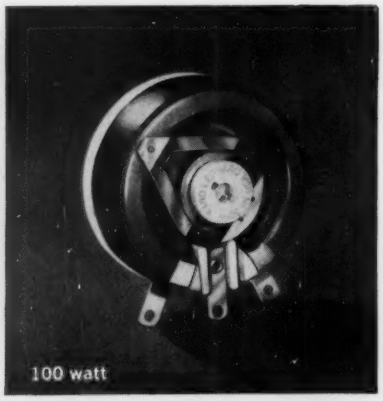
If you have questions—about designing with plastics for function, serviceability, economy and appearance—please ask us. We'll be glad to answer on the practical design and engineering uses of vinyls, epoxies, phenolics, styrenes, and polyethylenes. Just write or call any of our offices or write Dept. AW-050, Union Carbide Plastics Company, Division of Union Carbide Corporation, 30 East 42nd Street, New York 17, N. Y. *In Canada:* Union Carbide Canada Limited, Toronto 7.

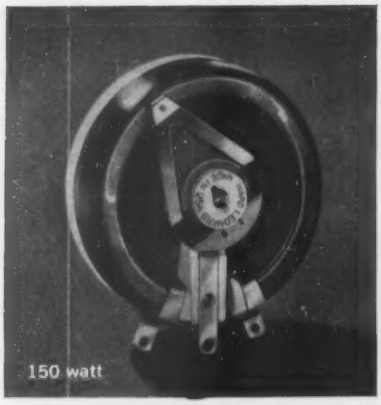
UNION CARBIDE

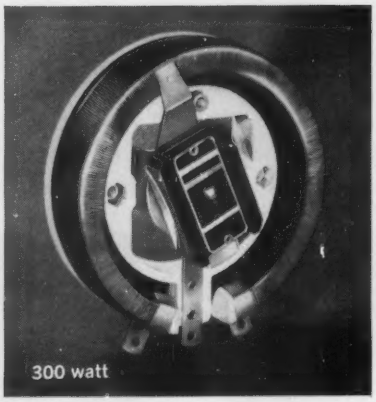
"Bakelite" and "Union Carbide" are registered trade marks of Union Carbide Corporation.

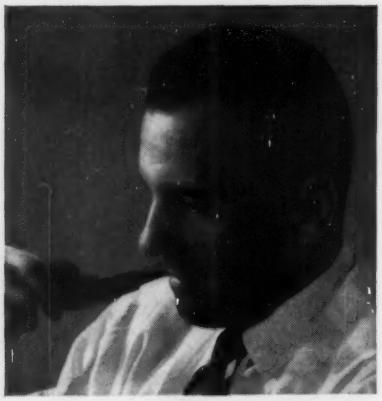




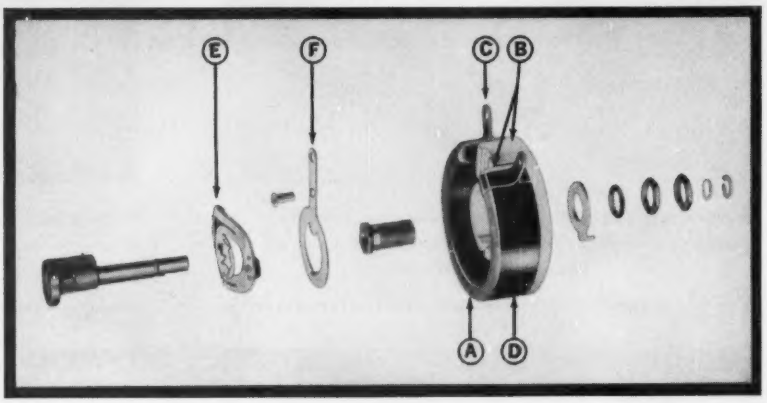








THIS IS A **RHEOSTAT** YOU CAN STAKE YOUR REPUTATION ON



From 25 to 300 watts these VITROHM ring rheostats are engineered for longest life, maximum reliability

To be sure about smooth, trouble-free control in the 25- to 300- watt range—just specify a VITROHM rheostat.

You get smooth control: Close-laid turns (A) of special high-stability, low-temperature-coefficient wire or ribbon to insure smooth gradual resistance change from zero to maximum.

You get reliability: VITROHM ring rheostats are engineered for permanence from highest-grade ceramic base and core (B), durably bonded, tinned-alloy terminals (C), to final craze-proof, shock resistant, long-lasting VITROHM bonding (D).

You get positive action: Self-lubricating twin-shoe contacts—exclusive with W/L—on balanced beryillium copper contact arm (E) eliminate backlash, contribute to smooth operation, minimize wear on resistance wire (A), assure positive contact to collector ring (F).

You get many more features than we can detail here. Check them all in W/L Bulletin 60RR (and, above 300 watts, check "plate rheostats" in Bulletin 60A). Either bulletin, yours for the asking. Ward Leonard Electric Co., 58 South St., Mount Vernon, N.Y. (In Canada: Ward Leonard of Canada, Ltd., Toronto.) o.e

WARD LEONARD
ELECTRIC COMPANY
MOUNT VERNON, NEW YORK

LIVE BETTER...*Electrically*

Result-Engineered Controls Since 1892

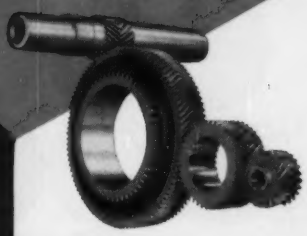
RESISTORS | RHEOSTATS | RELAYS | CONTROLS | DIMMERS

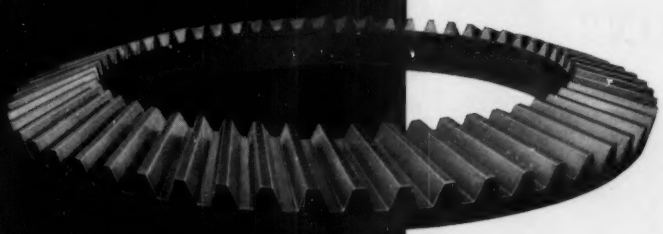
Circle 447 on Page 19

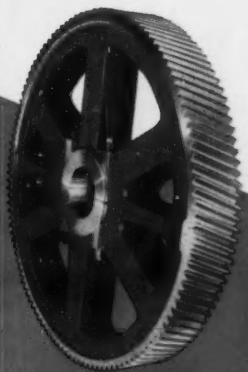
ILLINOIS GEAR has a world-wide REPUTATION

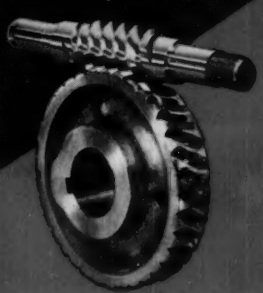
for Dependability and Superiority

. . . Proven by Performance









Back of every ILLINOIS gear is a tradition of dependability and superiority . . . a tradition that has become the priceless ingredient in the minds of men who specify, buy and use gears.

Wherever gears are used . . . the name ILLINOIS GEAR has become symbolic of a reputation . . . a matchless reputation that is known throughout industry and demonstrated by performance in all parts of the world.

If you are not now using or specifying ILLINOIS GEARS we invite you to profit from this background of quality and performance that has established a new concept in gear making.

Look for this mark ILG *. . . the symbol on finer gears*

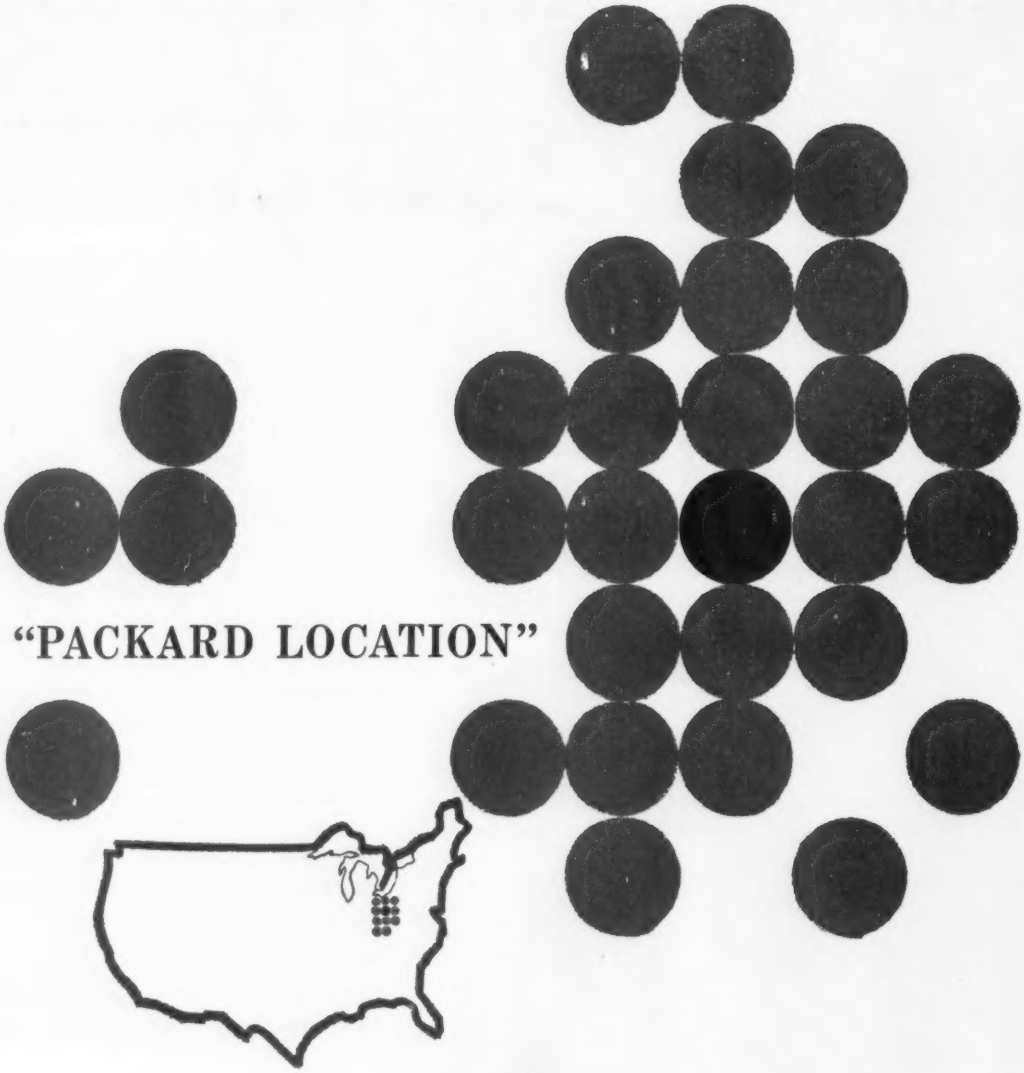
ILLINOIS GEARS Reg. U.S. Pat. Off.

Gears for Every Purpose **... one gear or 10,000 or more**

ILLINOIS GEAR & MACHINE COMPANY

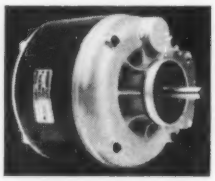
2108 NORTH NATCHEZ AVENUE • CHICAGO 35, ILLINOIS

Circle 442 on Page 19



"PACKARD LOCATION"

Steel, copper, rubber and plastic suppliers are next door. Also, we make our own magnet wire and cords. This helps us assure you of motor supply. Our neighbors, supplying steel, are only four miles away.



Other suppliers are located in nearby Sharon, Youngstown, Akron and Cleveland. "Packard Location," plus our effective distribution plan, gives you a dependable source of motor supply.

fractional horsepower motors by

Packard Electric

Warren, Ohio

GM GENERAL MOTORS

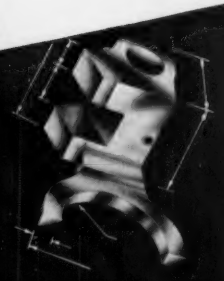
"Appliance Motor Specialists"

BUNTING® BEARINGS

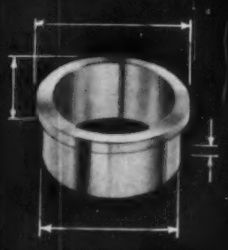
engineering for **both** cost and mechanical requirements in the bearing field . . .

Bunting can help you identify and procure the bearing or part that will do your job at the lowest possible cost. Often a re-examination of the actual mechanical needs of a bearing application reveals an opportunity to save money in design. Another saving is almost invariably achieved by considering ALL the new bearing materials which Bunting makes available to you today. Let Bunting help you engineer your bearing application in the light of modern availabilities. Send in your blueprints or ask for engineering counsel.

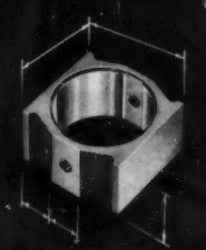
...case in point*



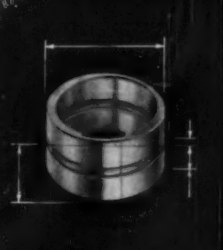
*Clearly evident is the economy in the production of this shifter fork by Bunting Powder Metallurgy. The elimination of machine work effects striking cost reduction.



*This cylinder gland bearing made of Bunting Bearing Aluminum is an example of how to save weight and money on the cost of large, thick-wall bearings and parts.



*This cast bronze cam block, made to unusually close limits with very fine finish, is absolutely round and true to size with cost at a feasible figure.



*Solid cast aluminum gear bearing to replace roller bearing for longer life and lower cost.

BUNTING ENGINEERS . . . Bunting maintains a staff of bearing engineers whose wide experience and specialized knowledge are available to you gratis for study and recommendation concerning your current or contemplated bearing applications.

Write for these:

NO. 158 • GENERAL CATALOG—Complete listings of Cast Bronze and Sintered Bronze Stock Bearings and Bars and Bunting Bearing Aluminum Bars. Pocket size edition.

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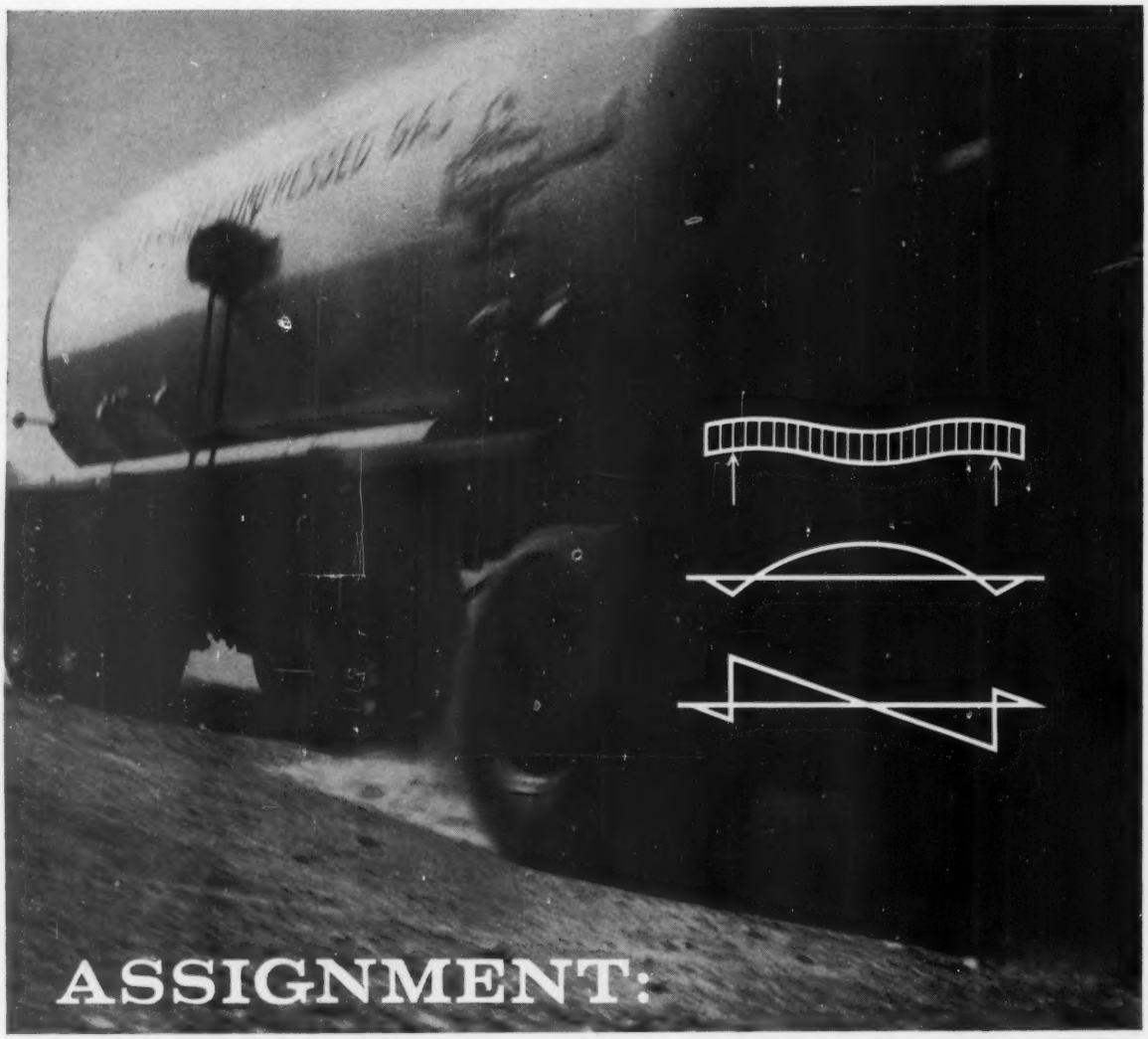
BEARINGS, BUSHINGS, BARS AND SPECIAL PARTS OF CAST BRONZE, SINTERED METALS OR ALUMINUM ALLOYS



STRENGTH/WEIGHT

How Lukens *Application Research* can help you find the right steel plate for the job

Designing for maximum payload means taking maximum advantage of today's high strength steels. Experts who know these steels—from a practical as well as technical standpoint—can give invaluable assistance in the early planning stages. This is the job of our Application Engineering staff.

LPG transport tanks and power shovels are widely divergent areas in which Lukens engineers have helped increase payloads.

The use of Lukens "T-1" steel plate and heads in tanks for hauling LP-Gas has fostered an entirely new design concept in the tank truck field. This high tensile, high yield strength steel (100,000 psi) makes it possible to mount wheels *directly on the tank.* The dead weight of heavy underframes goes into payload.

Working with a major producer of power shovels, our staff suggested tough Lukens "T-1" for buckets, dipper sticks, bucket teeth and other key parts. Lightweight, welded steel plate—rather than heavy castings—added as much as 40% to load capacity.

From these successful projects—and many more—our Application Engineers have gained knowledge and experience of value to design engineers. That's why we say... *if your assignment is strength/weight, let it be our assignment, too.* Contact Manager, Application Engineering, E-10 Services Building, Lukens Steel Company, Coatesville, Pa.

Helping Industry Choose Steels That Fit The Job

LUKENS

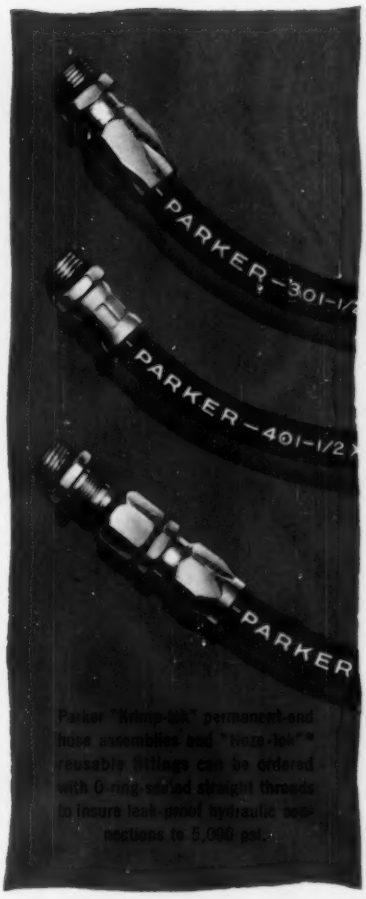
ASK FOR THE LUKENS "T-1" STEEL BULLETIN

Circle 451 on Page 19

For Fittings Information Circle 501 on Page 19→
For Cylinder Information Circle 502 on Page 19→

PARKER-HANNIFIN FLUID SYSTEM COMPONENTS

Hannifin high-pressure hydraulic cylinders feature a drip-free rod gland with "LIPSEAL"® and "WIPERSEAL." This feature, plus straight-thread, O-ring-sealed ports, insures leak-proof cylinder installations.



Parker "Krimp-lok" permanent-end hose assemblies and "Hoze-lok"® reusable fittings can be ordered with O-ring-sealed straight threads to insure leak-proof hydraulic connections to 5,000 psi.

from **PARKER-HANNIFIN...**

straight-thread ports and fittings

for leak-proof

hydraulic systems

Both Parker "Triple-lok"® flare-type and "Ferulok"® flareless fittings include straight-thread shapes in steel and stainless steel for leak-free tube connections. Write for our handy "Fittings Finders" for quick selection of Parker tube fittings, hoses and hose fittings.

Parker straight-thread hydraulic fittings, mated with S.A.E. bosses (offered at *no extra charge* on Hannifin cylinders), guarantee leak-proof cylinder port connections.* This use-proved sealing method is J.I.C. recommended.

To insure leak-proof performance throughout your hydraulic systems, Parker offers both "Triple-lok" flare-type and "Ferulok" flareless fittings for leak-proof tube connections. Where you need high pressure, permanent-end hydraulic hose assemblies, Parker supplies "Krimp-lok." And for fast, leak-proof field service or replacement, Parker "Hoze-lok" fittings require no skiving of the hose, need a minimum of tools for assembly.

Your Parker-Hannifin man is qualified to help you with installation problems. He'll also help you plan your hydraulic layouts.

**Both Parker fittings and Hannifin cylinders are still available with "dry-seal" pipe threads.*

Parker FITTINGS AND HOSE DIVISION
17325 Euclid Avenue, Cleveland 12, Ohio

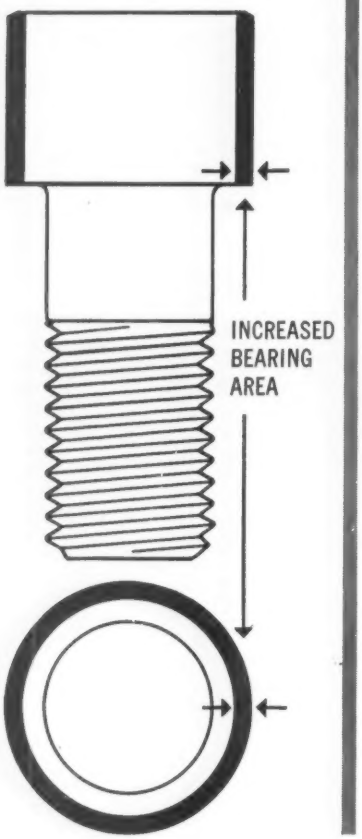
HANNIFIN COMPANY
545 S. Wolf Road, Des Plaines, Illinois

DIVISIONS OF PARKER-HANNIFIN CORPORATION

A MAJOR DEVELOPMENT IN SOCKET CAP SCREW DESIGN!

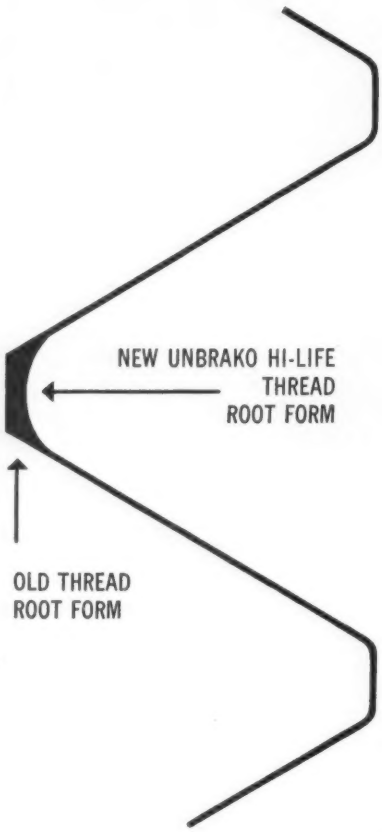
UNBRAKO *pHd** with Hi-Life thread— the advanced fastener for the 60's

Stronger in the head



UNBRAKO pHd design features increased bearing area under the head, bigger wrenching socket; provides up to 2⅓ times as much holding power without indenting bolted material. By permitting higher preloading, pHd helps eliminate fatigue failures, reduces possibility of screws working loose under shock and vibration.

Stronger in the thread

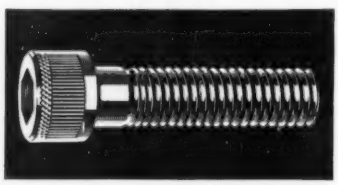


New UNBRAKO Hi-Life thread form has smoothly radiused root, slightly more metal at minimum cross section. Result: up to 100% greater fatigue life, plus a bonus in added tensile strength. Only UNBRAKO gives you the new, larger pHd head design and the improved Hi-Life thread . . . in a standard screw at no extra cost.

Anticipating tomorrow's demands today, SPS now offers you a standard socket head cap screw that incorporates both the UNBRAKO pHd design (1960 Series) *and* the new UNBRAKO Hi-Life thread.

This combination gives you a fastener that is unequaled in strength and performance. Because of its increased bearing area and bigger socket, you can tighten it tighter without deforming screw or bolted material. Thus you get more holding power—up to 2⅓ times as much, in fact. And because of both increased bearing area *and* new radiused thread root, the UNBRAKO pHd Hi-Life is almost twice as strong in fatigue.

The pHd head and Hi-Life thread —both originated by SPS—are tangible results of a continuing program of basic research in the design and performance of threaded fasteners. And they reflect to no little degree SPS experience in developing special high-strength fasteners for aircraft/missile use. Nevertheless, this new UNBRAKO is available to you as a standard—at no increase in price. For complete data, write SPS—manufacturer of precision threaded fasteners and allied products in many metals, including titanium.



New UNBRAKO pHd socket head cap screws with Hi-Life thread are available now from your authorized industrial distributor in standard sizes ¼ through 1 inch, plain or cadmium plated. Available also with the Nylok† self-locking feature. NOTE: UNBRAKO pHd Hi-Life screws fit standard tapped holes, require no special gaging.

†T.M. Reg. U.S. Pat. Off., The Nylok Corporation

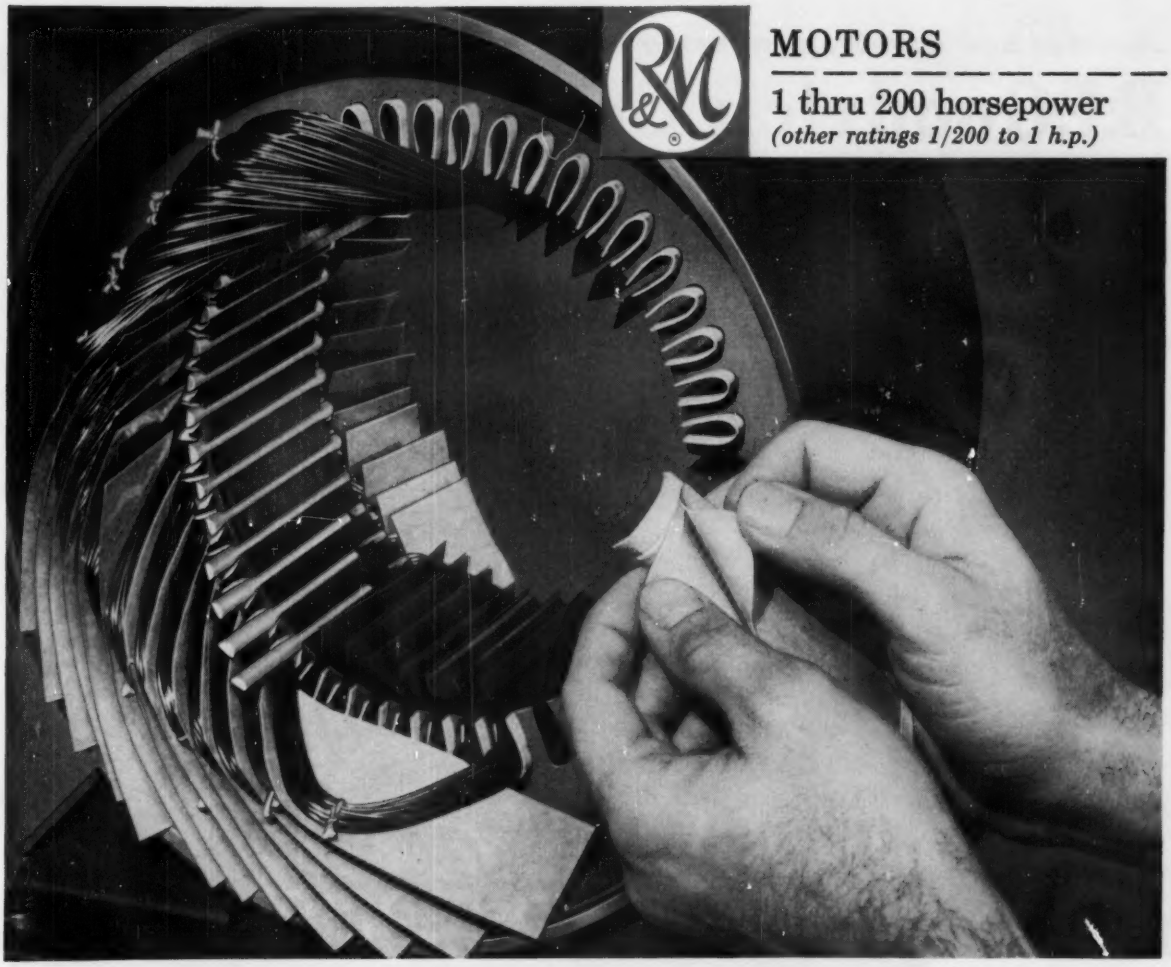
INDUSTRIAL FASTENER Division

JENKINTOWN 18, PENNSYLVANIA

SPS

*pHd stands for "proper head design"—a factor in higher product reliability

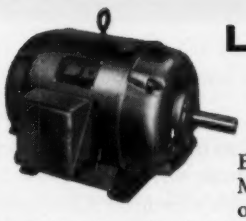
Circle 453 on Page 19



MOTORS

1 thru 200 horsepower

(other ratings 1/200 to 1 h.p.)

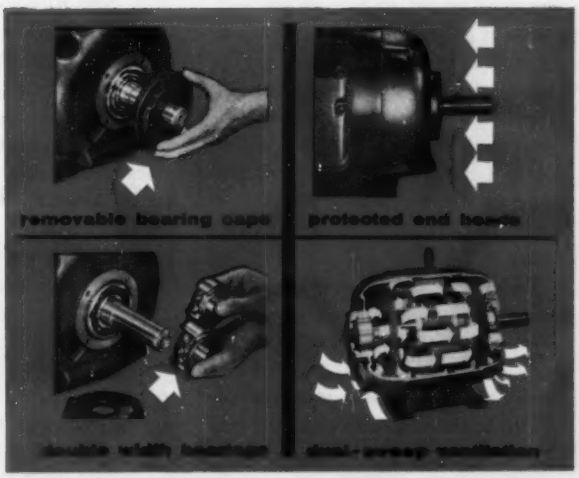


Locked-In, Laminated Insulation

Insures Longer Life for your R&M Motor!

Each slot-cell in your ROBBINS & MYERS motor grips a triple layer of insulation around the windings. Installing these insulation "sandwiches" is a time-consuming job but it pays off in long motor life. Mylar* laminated to rag paper is first inserted. Reinforced edges prevent slipping and scuffing. The dielectric qualities of Mylar* (8 times that of conventional insulation) combined with its resistance to tearing and aging affords permanent protection; the rag paper backing acts as a cushion against abrasion and punctures. A second layer of insulation is inserted to eliminate the danger of weak spots. The wire coil, coated with triple resin insulation, is inserted and a third layer of insulation is placed over it. Insulation is placed between the coil ends, wedges are inserted to hold the coil firmly in place and the stator is twice dipped in special insulating varnish and baked after each dip, thus forming an armor-like coating. Coil ends are coated with a moisture-proof sealer. This is insulation you can trust, yet it's yours at standard prices! For more details write for Bulletin 520 MD

**DuPont registered trademark*



ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

Circle 454 on Page 19

Another new development using

B.F.Goodrich Chemical *raw materials*

Coustifab is a lead-filled Geon coated fabric for vibration deadening. It is made by Cordo Chemical Corporation, Norwalk, Conn., and is illustrated here in ceilings and at base of side panels on the aft part of Douglas DC-8 cabins. B.F.Goodrich Chemical Company supplies the Geon polyvinyl material.

LEAD-LOADED GEON COATED FABRIC DAMPENS VIBRATIONS ON NEW DC-8

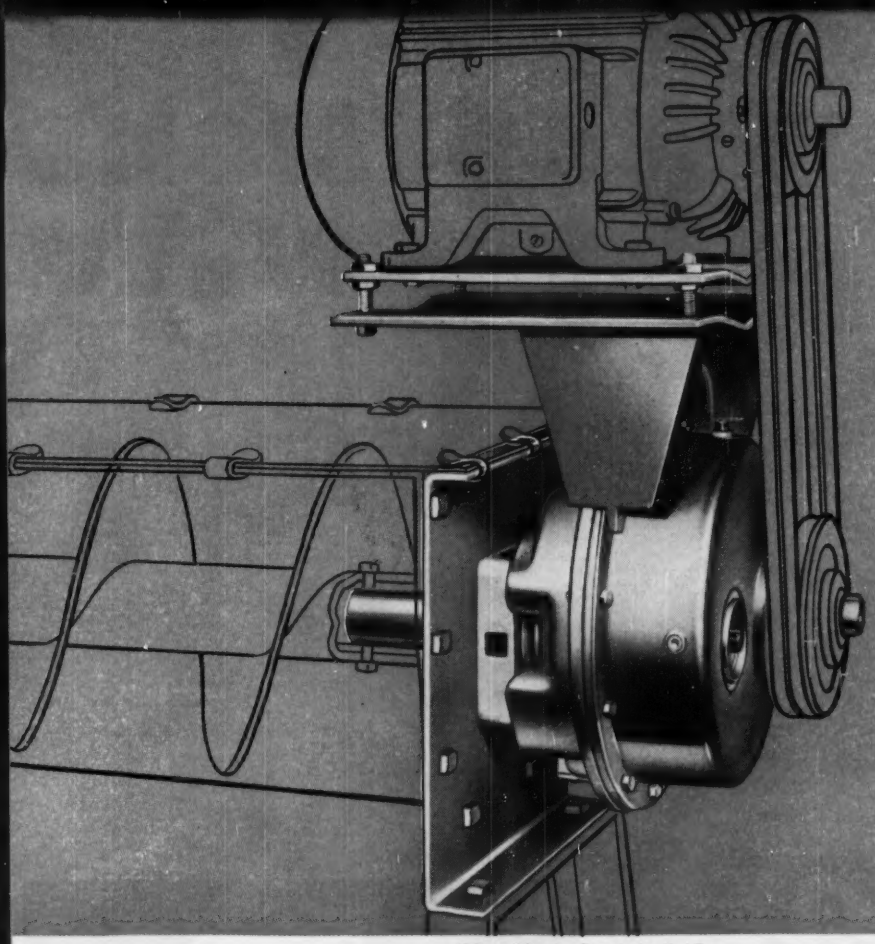
The roar of jet engine power and speeds of jetliner operation are creating entirely new design problems for engineers charged with dampening vibration and sound. Douglas engineers are solving the problem with a new flexible fabric which dissipates the low frequency vibrations that ordinary acoustical material can't screen out.

The material consists of either cotton or glass fabric coated with a Geon polyvinyl material that has been compounded with powdered lead. This construction provides sufficient barrier mass to dampen and to provide increased transmission loss, yet offers considerably improved flexibility—unlike former materials that actually contained a potentially friable sheet of lead as an inner core or a central layer.

Geon has proved best for this application because it disperses readily in the coating formula, providing excellent coating characteristics and a good bond with the fabric. Versatile Geon provides coatings for many products—from metal to non-woven fabrics. Or you can use Geon to make products like insulated wire, pipe, or foam. A wide variety of resins, compounds, latices and polyblends is available. For the type best suited to improve your product or application, write Dept. GW-1, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, Ohio. Cable address: Goodchemco. In Canada: Kitchener, Ontario.

B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich GEON polyvinyl materials • HYCAR rubber and latex • GOOD-RITE chemicals and plasticizers



NEW! FALK Screw Conveyor Drive

U.S. and Foreign Patents Applied For

–the drive our customers asked for

Our customers helped us design this new unit. We sent our men into the field to find out what our customers needed in a screw conveyor drive—then our engineers designed a new drive that offers the maximum of service, versatility, operating economy and long life. Here are some of its outstanding features:

A COMPLETE DRIVE: Saves engineering and assembly time. Six sizes to cover entire range—each with these ratios: — 4:1, 9:1, 14:1 and 24:1. Bolts to any standard trough end—eliminates trough end bearing. Eliminates drive shaft wobble. Efficient FALK single helical gears.

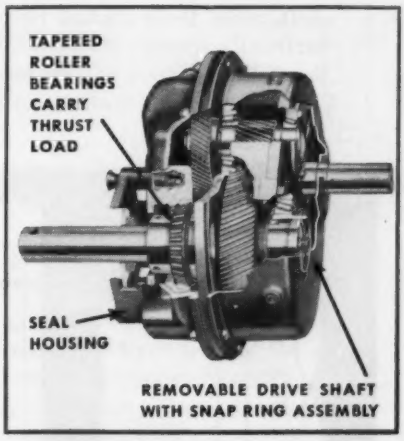
SEAL HOUSINGS: Choice of seals (neoprene or leather lip, felt or waste) to accommodate material conveyed. Space between trough seal and unit seal prevents conveyed material from reaching unit seal.

REMOVABLE DRIVE SHAFT: Snap ring assembly permits easy removal. Five sizes, from 1½" to 3 7/16".

TROUGH END: Can be fastened to any standard trough. Eight sizes, from 6" to 20".

ALL-STEEL MOTOR MOUNT: Saves costly engineering and installation time and costs; no motor plates to design or fabricate. Motor can be mounted in virtually any position. Pre-drilled to accommodate NEMA standard motors ½ to 30 HP.

AN IMPORTANT ECONOMY: Buy only what you need—the basic reducer alone, or with trough end and/or motor mount. For detailed information, contact your Falk Representative or Distributor—or ***write direct for Bulletin 7106.***



THE FALK CORPORATION, MILWAUKEE 1, WISCONSIN

MANUFACTURERS OF QUALITY GEAR DRIVES AND FLEXIBLE SHAFT COUPLINGS

Representatives and Distributors in most principal cities

Circle 456 on Page 19

FALK is a registered trademark

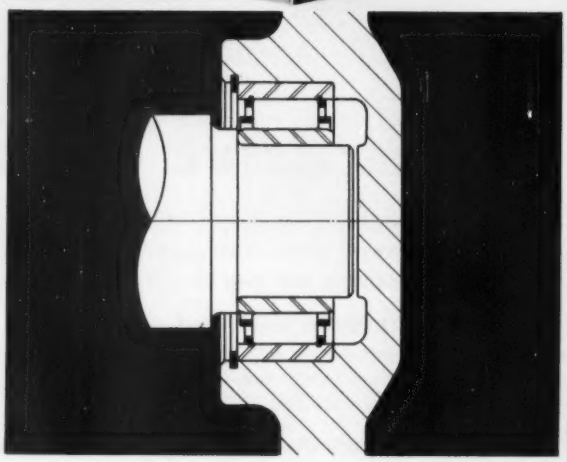
FALK

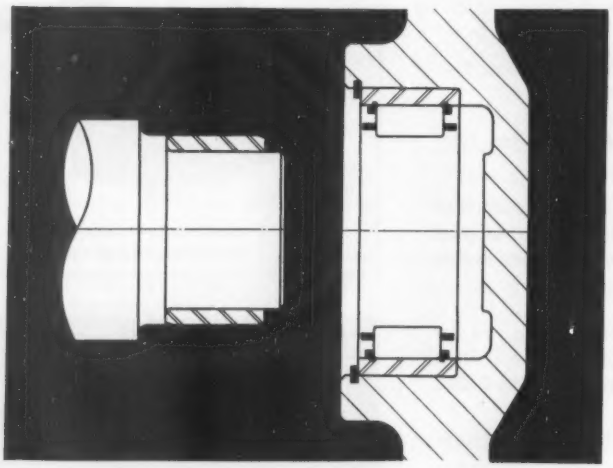
...a good name in industry

DESIGNS WHEN

SAVES COSTS

Notice how simple this speed reducer becomes when you start using Hyatt Hy-Roll bearings. It's easy to design, quickly drawn and requires no costly end clamps, threads, nuts, screws or washers. That's because Hyatt Hy-Roll bearings can be affixed to the shaft with a heavy press fit . . . to become, for your purposes, actually part of the shaft. Since Hyatt Hy-Roll races are made from case-hardened, low carbon steel, rather than through-hardened, they will never crack or come loose.

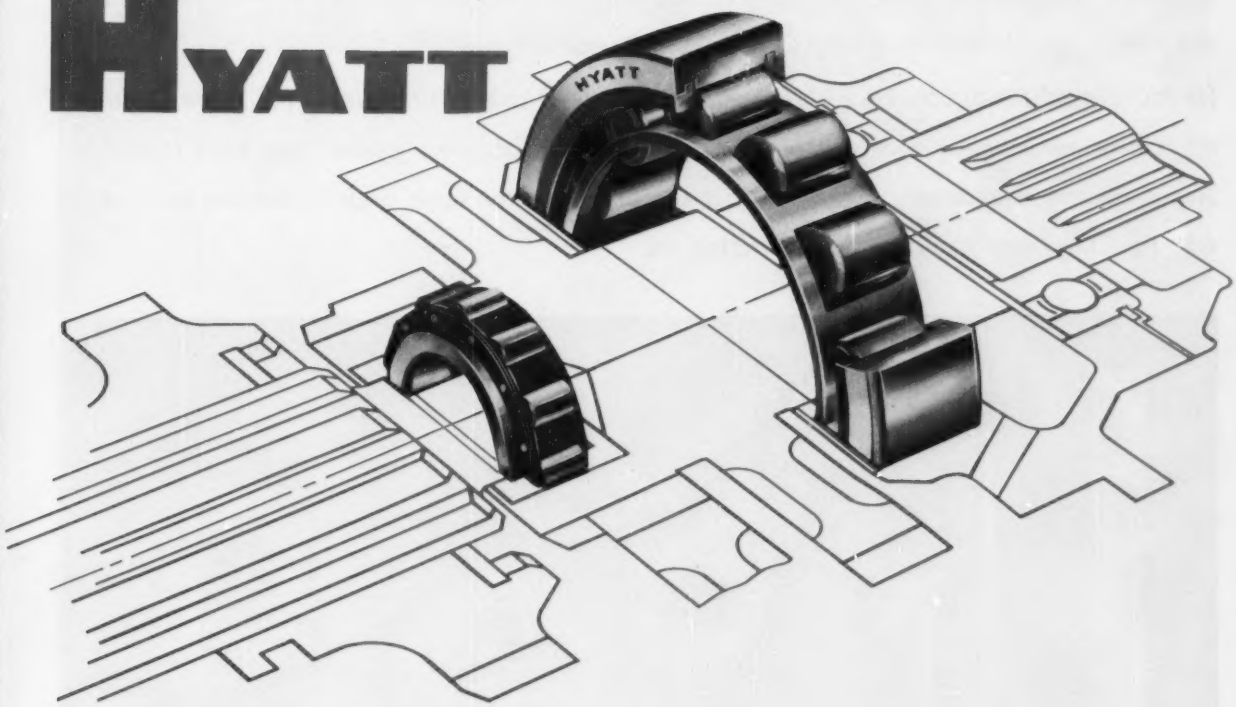




SPEED-UP PRODUCTION

Look ahead to the time when this same speed reducer goes into production. Then you'll see why Hyatt makes all separable races interchangeable within the same part number. For it allows you to press the race on the shaft at one work station, then fit it into any of the mating assemblies already installed in the housing at another station. You don't have to worry about matched assemblies because Hyatt has made selective fits a thing of the past. Think of the time it saves!

CAN BE SIMPLER YOUR "SPECS" READ HYATT



SAVE SPACE

Here's the type of design problem you'll see every day. The horsepower has been increased, so this transmission input shaft must have a larger diameter and the pilot bearing must have added capacity. Yet both modifications must be made *without an increase in overall dimensions.* Sounds difficult, doesn't it? But only until you start using Hyatt Hy-Roll Bearings with separable races!

For increased bearing capacity, use a larger Hyatt BU-type bearing at the pilot and eliminate the outer race. Then specify a Hyatt TS-type bearing for the input shaft. By eliminating the inner race, you have more than enough room to increase the shaft diameter. And both changes are made without increasing the size of the gears or the housing! This is the perfect solution wherever you can harden and grind the mating surfaces to bearing race specifications.

Hyatt produces 10 major bearing types—four have separable inner races

—four non-separable

—and two have separable outer races.

The separable race can be omitted and rollers operated directly on the shaft or in the housing bore, in instances where the bearing surfaces can be brought to suitable hardness and finish.

For full details on selection and application of these bearings see Hyatt Catalog 150 or call your nearest Hyatt sales engineer.

Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey

HYATT HY-ROLL BEARINGS

IN ROLLER BEARINGS HYATT IS THE WORD FOR GM GENERAL MOTORS RELIABILITY

Circle 457 on Page 19

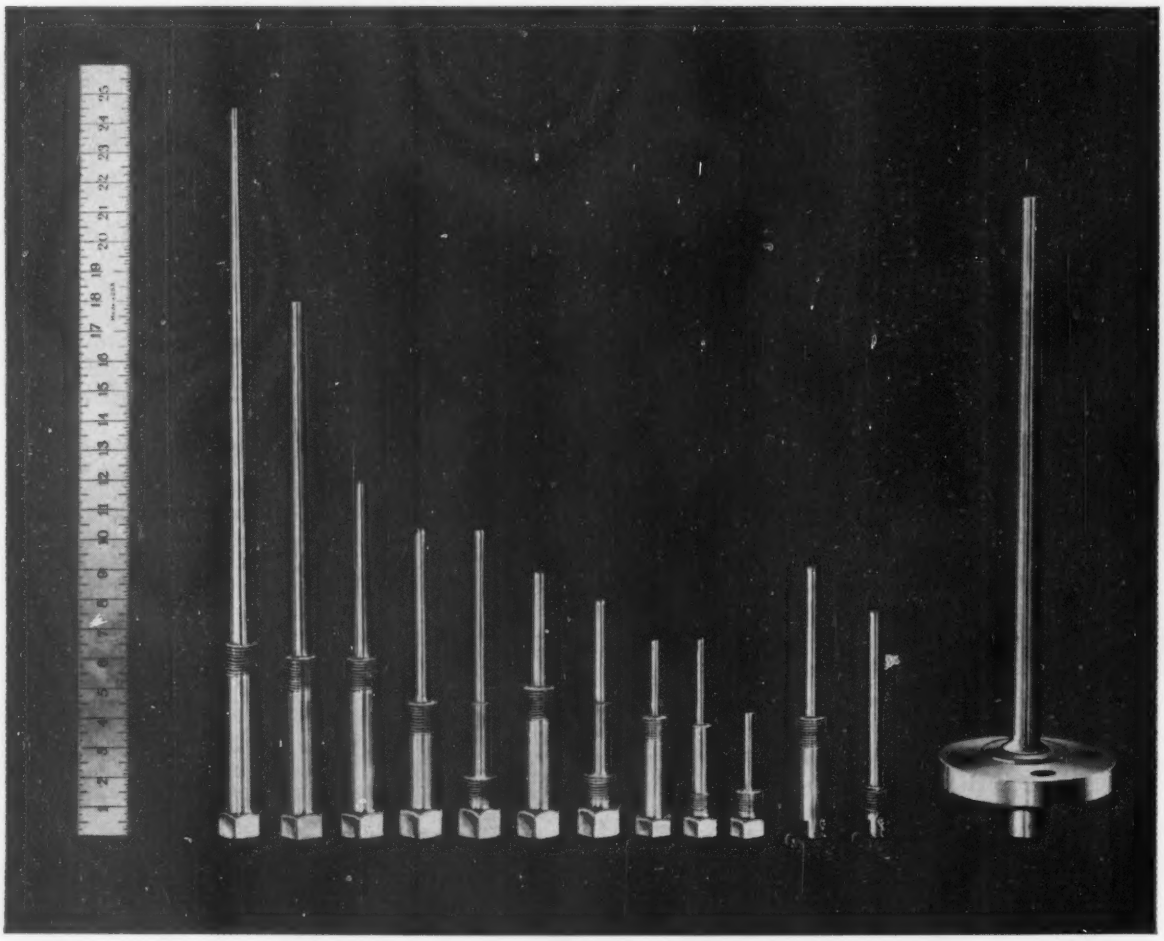
for uniform machinability, strength and oxidation resistance

...it had to be Stainless

Drilling blind 3/16" holes down through thermocouple wells up to two feet long can be a heart- (and profit-) breaking job unless the steel is truly uniform. Uniform machining qualities were the fabricator benefits that brought Carpenter Stainless No. 4 (Type 302) and No. 8 (Type 303) into the picture. The benefits that keep Carpenter in the picture are:

(1) increased production (2) lower costs (3) less machining time (4) fewer rejects

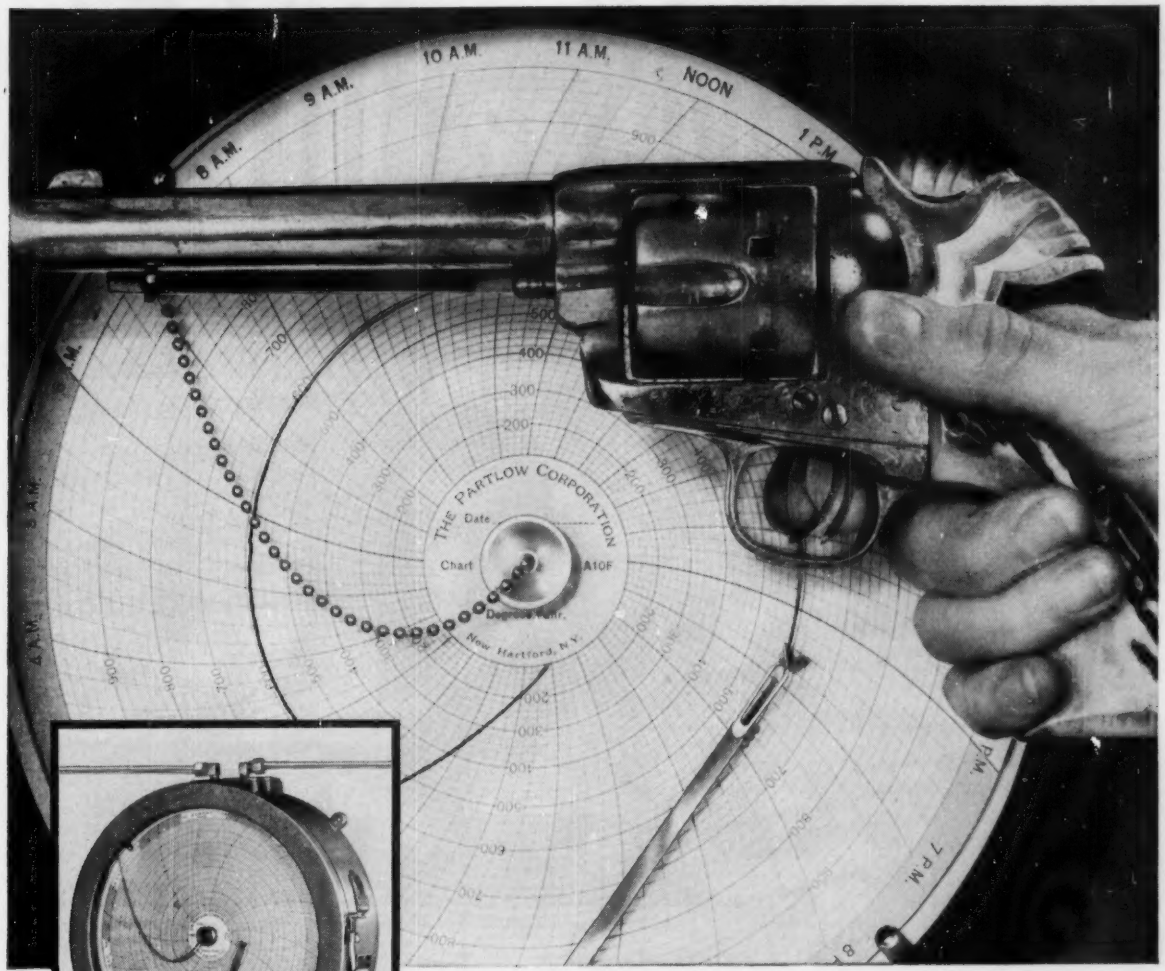
all evident immediately after switching to these Carpenter stainless grades. Your local Carpenter Representative may have a suggestion that can bring you the same kinds of benefits on a tough job. The Carpenter Steel Company, Reading, Pa.

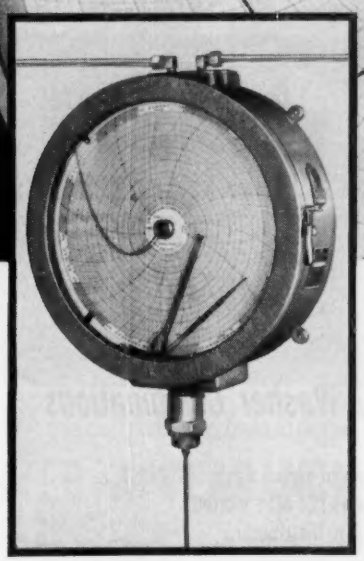


a new company 70 years old

Carpenter steel

The Carpenter Steel Company, Main Office and Mills, Reading, Pa.
Alloy Tube Division, Union, N. J.
Webb Wire Division, New Brunswick, N. J.
Carpenter Steel of New England, Inc., Bridgeport, Conn.





The Control Geared for

HAIR TRIGGER RESPONSE

even to Fractional Changes in Temperature!

NEW *Recording Pneumatic Temperature Control, Model RVA, available in any of 10 ranges from -30° to 1100° F.*

Extreme sensitivity—reflected in lightning-fast reaction to temperature changes—is a characteristic of *all* Partlow controls. Partlow Recording controls, however, *prove it in writing* . . . You can see for yourself how exceptional bulb sensitivity, teamed with advanced mechanical design, provide a minimum of "saw-toothing" on start-up, and maintain a rigid line of control when temperature reaches a predetermined set point.

Instant response, of course, is just one of Partlow's many built-in advantages. Another is rugged *design simplicity* that does away with hair springs and delicate electronic gadgets . . . that requires no electronic amplification . . . that permits fast, "screwdriver" replacement of the thermal element *right out in the field.*

If you use or manufacture process equipment within the -30° to 1100° F. range, there's a Partlow Pneumatic, electric or self contained gas control to fit your application *precisely*. Recording, indicating and non-indicating models available. For full details write The Partlow Corp., New Hartford, New York, Dept. D-160.

Export: Ad. Aurlema, Inc., 85 Broad St., New York 4, N. Y.

You can pay more but you can't buy better than

PARTLOW

TEMPERATURE CONTROLS

FOR SEMS...BUY P-K®

All Types of SEMS and Pre-assembled Fastener-Washer Combinations

Whatever you require in pre-assembled washers... SEMS, and neoprene or nylon washer STAPS®... in thread-forming and thread-cutting tapping screws, or machine screws... with slotted, Phillips or Hex heads... P-K can supply them-all through your local P-K Distributor.

P-K SEMS reach your assembly line pre-assembled, ready for instant use. Washers cannot come off—can never be mislaid or misplaced—insures washers on screws...not on the floor! Double inventory and double parts handling is completely eliminated.

P-K SEMS can be hopper fed for automatic driving. Inspection rejects due to omitted lock washers are impossible—fastenings stay tight and firm. P-K Sems assure concentric washer seating.

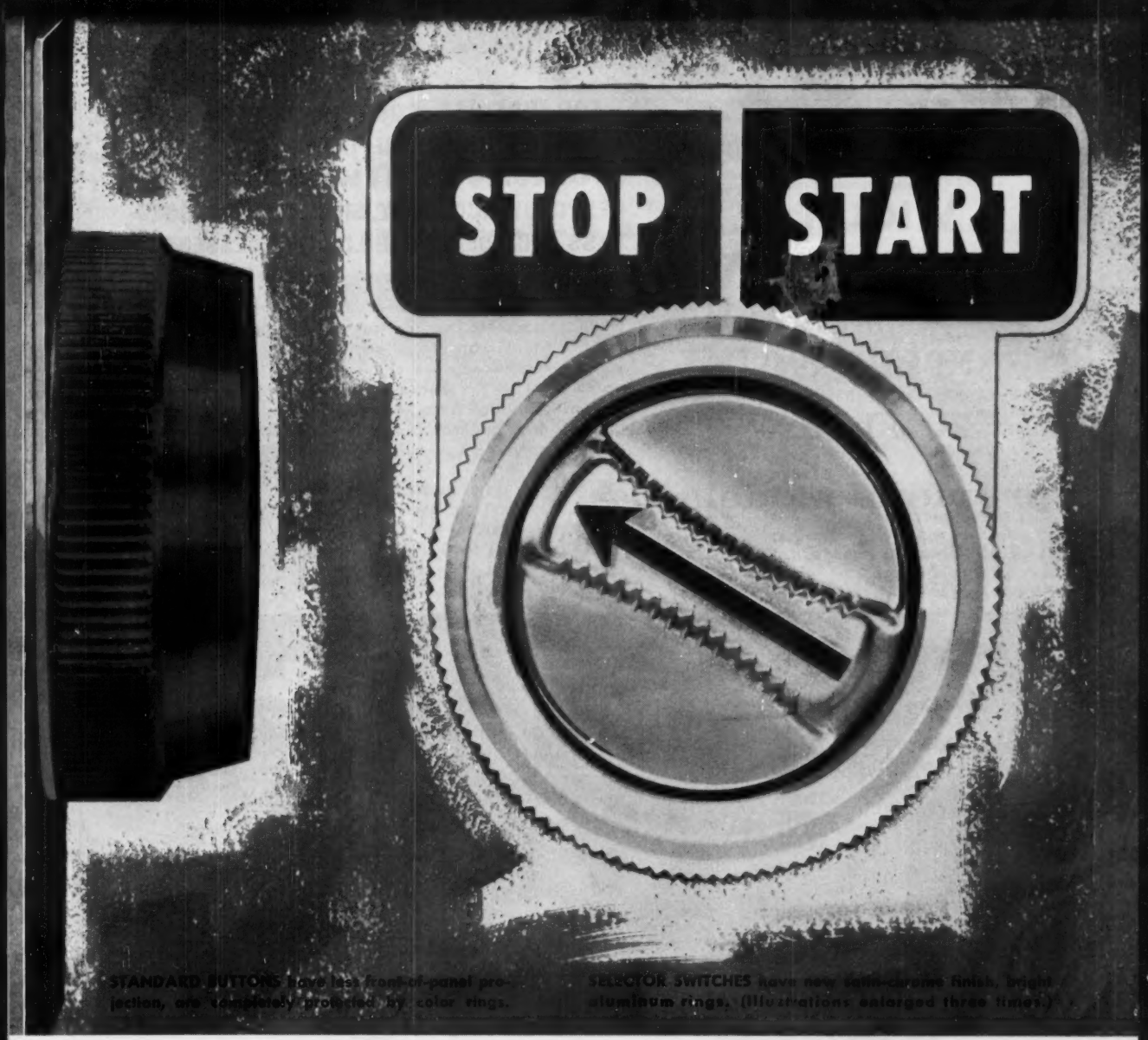
STAPS® are standard P-K fasteners, pre-assembled with nylon or neoprene washers for effective control of leaks, squeaks, crazing and electrolysis, in all types of metal structures and assemblies.

Your nearby P-K Distributor can meet your needs. Call him for samples and complete information.

PARKER-KALON® fasteners

Keep American Industry at Work... Buy P-K... made in U.S.A.

PARKER-KALON, a division of General American Transportation Corporation, Clifton, New Jersey. Offices and warehouses in Chicago and Los Angeles.



STANDARD BUTTONS have less front-of-panel projection, are completely protected by color rings.

SELECTOR SWITCHES have new satin-chrome finish, bright aluminum rings. (Illustrations enlarged three times.)

Three "measurable advantages" of General Electric CR2940 Oil-tight Pushbuttons:

BETTER APPEARANCE, GREATER SAFETY, MORE FLEXIBILITY

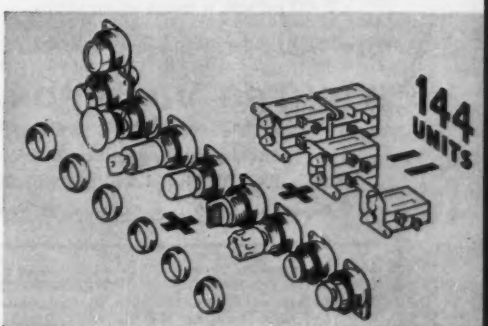
When your machines, consoles or panels include CR2940 General Electric oil-tight pushbuttons, you've built in an extra sales advantage that will improve customer acceptance of your products.

The outstanding appearance of G-E units is the result of several exclusive features: pushbutton color coding is permanently anodized on color rings to prevent loss of identification due to dirt and grime, and to provide positive all-angle color identification; new satin-chrome finish on selector switches and bright aluminum rings resist corrosion and wear, blend well with machines or panels.

The rugged, all-metal standard pushbutton operator hugs the panel to avoid accidental damage. Protected buttons also guard against unintentional operation. Write for bulletin GEA-5779, General Electric Company, Schenectady, New York. 731-20

You get
MEASURABLE ADVANTAGES
WITH GENERAL ELECTRIC CONTROL

GENERAL ELECTRIC



BUILDING BLOCK CONSTRUCTION cuts your stock needs. Just 6 color rings, 8 operators, 3 contact blocks, provide 144 different units. Units can be front- or back-mounted. Variety of separable nameplates adds further versatility.

Circle 461 on Page 19

an improved

VICKERS.

SERVO VALVE

...yet priced

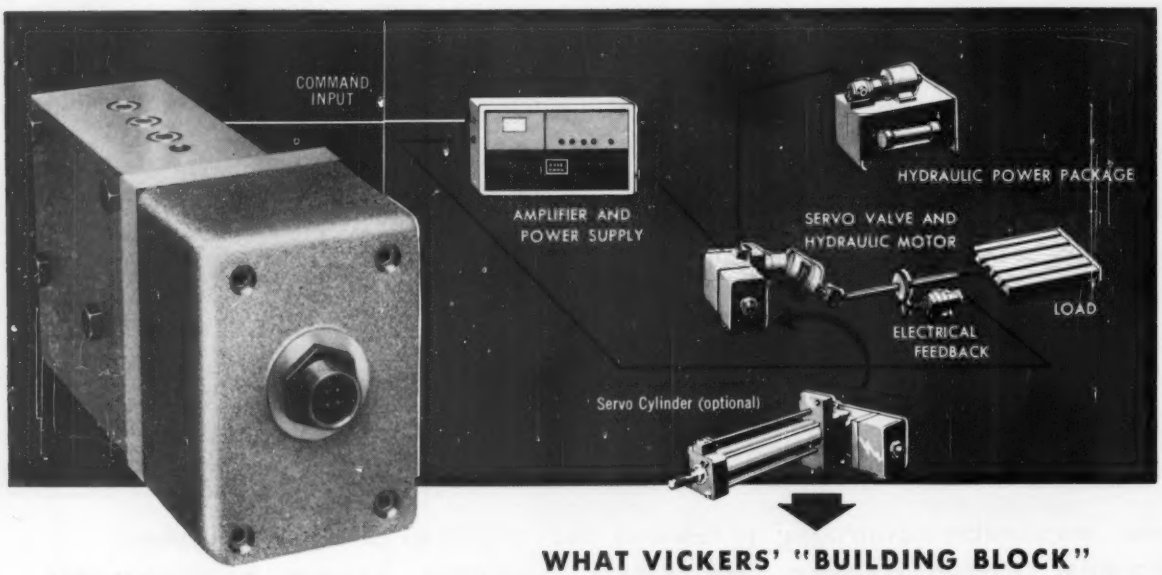
20% below

previous models

FOR PRECISE CONTROL OF OIL FLOW IN INDUSTRIAL, MILITARY AND MARINE HYDRAULIC SYSTEMS WHERE HIGH RESPONSE, ACCURACY, SIMPLICITY, RUGGEDNESS AND DEPENDABILITY ARE ESSENTIAL

Input signal to this improved Vickers electro-hydraulic servo valve can originate from a simple calibrated potentiometer or a sophisticated magnetic or punched tape reader system—yet the result is always extremely precise hydraulic flow proportional to the electrical command. This valve can be applied to a broad array of machine tools, process equipment and ordnance applications and is compatible with the wide range of command input methods commercially available.

There are only four moving parts in the two-stage, spool assembly of the Vickers servo valves, thus providing a simple, contaminant tolerant, exceptionally reliable operation. Get details by writing for Bulletin 59-74.



Available in models for flows to 37 gpm and suitable for operation at pressures to 3000 psi with a choice of mountings.

WHAT VICKERS' "BUILDING BLOCK" CONCEPT MEANS TO YOU

These pre-engineered electro-hydraulic servo systems offer positional accuracies of ±.0015-inch; and down to ±.0005-inch using the same standard components but with additional "trim." Your cost for Vickers "Building Block" systems is far below that normally associated with this degree of accuracy and response. These systems are specifically designed for heavy duty, industrial use.

Plug-in elements make trouble shooting and maintenance easy. Vickers' worldwide service organization insures unmatched backup for your personnel when required.

Why not contact the Vickers office near you today for more facts?

TYPICAL APPLICATIONS

Controlling velocity in processing applications • controlling position of machine tool slides and tables • programmed control of work handling and machine sequencing.

VICKERS INCORPORATED
DIVISION OF SPERRY RAND CORPORATION
Machinery Hydraulics Division
ADMINISTRATIVE and ENGINEERING CENTER
Department 1430 • Detroit 32, Michigan

Application Engineering Offices: ATLANTA • CHICAGO AREA (Bensenville)* CINCINNATI • CLEVELAND • DETROIT* • GRAND RAPIDS • HOUSTON INDIANAPOLIS • LOS ANGELES AREA (El Segundo) • MILWAUKEE NEW YORK AREA (Springfield, N.J.)* • PHILADELPHIA AREA (Media) PITTSBURGH AREA (Mt. Lehanon) • ROCHESTER • ROCKFORD • SAN FRANCISCO AREA (Berkeley) • SEATTLE • ST. LOUIS • WORCESTER
Factories also in: Australia, England, Japan and Germany
In Canada: Vickers-Sperry of Canada, Ltd., Toronto,* Montreal and Vancouver
Field Service Headquarters Underlined. Whse. Stock & Repair Branches*.

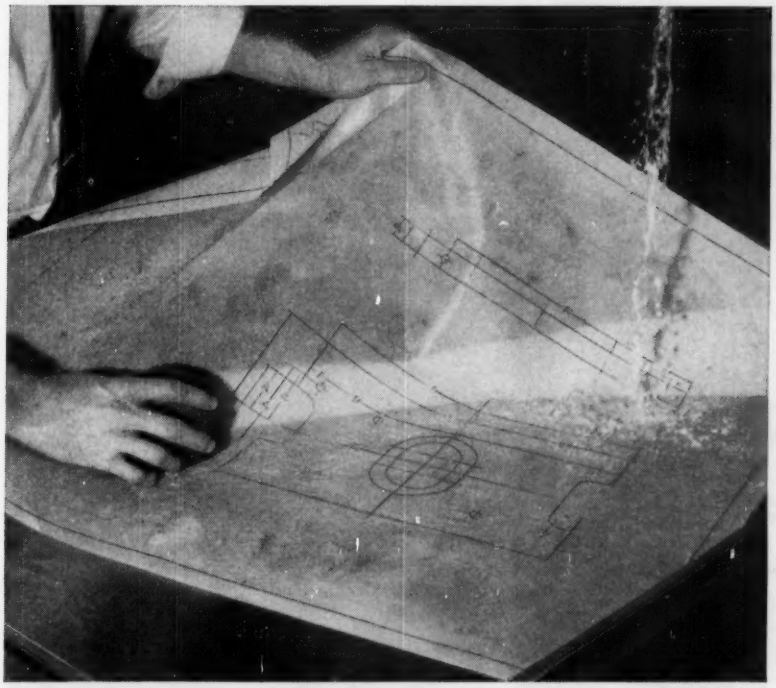
8479

ENGINEERS AND BUILDERS OF OIL HYDRAULIC EQUIPMENT SINCE 1921

Circle 462 on Page 19

Some Ideas

for your file of practical information on drafting and reproduction from
KEUFFEL & ESSER CO.



This badly-soiled drawing is getting a mild soap-and-water bath to restore its original printing quality.

Tracings you can wash! Mention this to a Chief Draftsman and you'd likely see his eyes light up as he perceives the implications of a simple new technique – one that's being used now by Raytheon Co. and could save them at least $50,000 this year. The secret: Herculene® Drafting Film by K&E, plus Staedtler Duralar plastic pencils –a completely washable combination, and the answer to . . .

A Dirty Old Problem

Functionally, an engineering drawing is only as good as the prints it will produce. This is a fact of life that governs any distribution-print system – conventional blueprints, white prints, or reduced-size prints. It holds true in a full-fledged miniaturization program, too. How long will an original tracing continue to produce top-notch prints? The answer depends on how much and what kind of handling it receives. Revisions, smudging, processing and filing all take their toll of a drawing's printability, decreasing it gradually – and sometimes quite sharply. As printing quality diminishes, some form of rehabilitation becomes necessary. But re-drawing – whether manual or photographic – can be costly and time-consuming. Drafting and reproduction experts have been wishing and working for a more efficient and economical solution.

A Simple Solution: Soap-and-Water

Washing became a possible answer with the advent of polyester-base drafting films and plastic pencils – and a practical reality with Herculene. This remarkable film combines a stable, waterproof Mylar® base with a completely washable surface for smudge-proof Duralar pencil lines – which *bond* to the Herculene surface and won't wash off.

Only the dirt washes away. There's no loss of line-background contrast, no loss of detail. The tracing can be restored to its original condition in a few moments – without re-drawing!

A Proved Money-Saver

To amplify an earlier point: the Missile Systems Division of Raytheon has been washing Herculene drawings for the past year, and now expects to save over $50,000 on re-draws alone in the year ahead. A large aircraft manufacturer has used the Herculene-Duralar soap-and-water method even longer, and reports impressive dollar savings plus an outstanding improvement in print quality.

In 6 months of testing and 14 months of actual drafting-room use, Raytheon engineers exposed Herculene to all basic trials – and a battery of fiendishly extreme conditions. They scored Herculene with a sharp scriber, but couldn't remove the matte surface. They taped a sheet to the floor and had a 200 pounder roll over it in a swivel chair during an active day. Herculene was baked and frozen – and doused with hot coffee – with no effect on its surface. After two hours, the coffee stain was washed off without a trace. Results of these torturous tests were so favorable that now, Raytheon's Missile Systems Division uses practically no drafting film *but* Herculene!

A Note of Caution

There are other waterproof drafting films, but plastic pencil lines will wash off some of them. So, when comparing polyester-base films, it's best to check them for *pencil line washability*. And another point – don't try this technique with ink or graphite lines – use only the Duralar K1 or K2. Even if you don't want to adopt the washing technique immediately, you're free to make the change at any time if you use Herculene – the *indestructible* drafting medium with the washable, engineered surface.

More Merciless Testing Invited

We'd be pleased to send you a sample of Herculene, and we invite you to do your best to ruin its excellent drafting and printing quality. The Herculene sheet comes in a small folder with complete instructions and a water-fast Duralar pencil – which K&E engineers helped develop for use with washable Herculene Drafting Film. Mail the coupon below for your sample!

KEUFFEL & ESSER CO., Dept. MD-1, Hoboken, N. J.

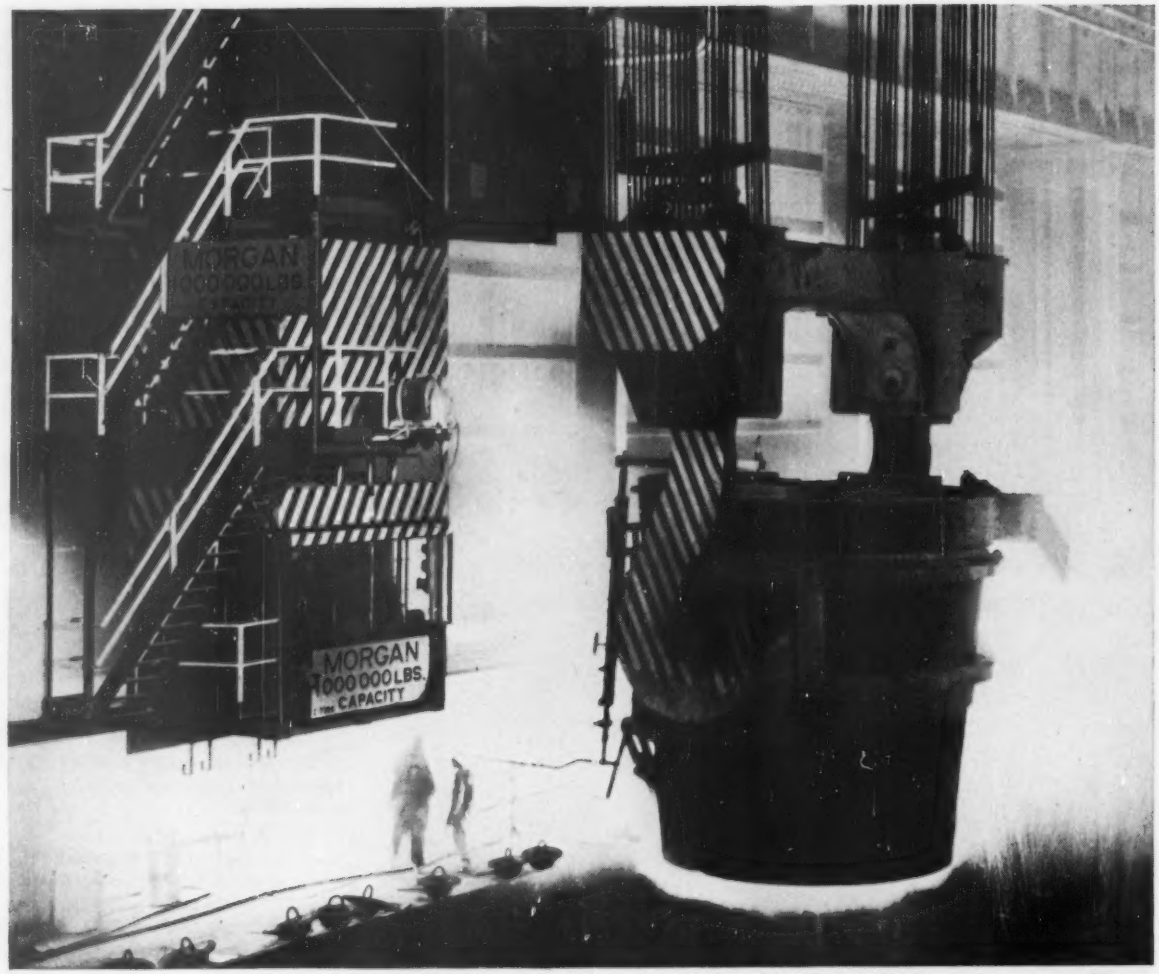
Please send me further information about the washable tracing method, plus a sample sheet of Herculene Drafting Film and a Duralar pencil.

Name & Title_____

Company & Address_____

_____ 1509

Circle 463 on Page 19



Repeated million-pound loads in the intense heat from 375 tons of molten steel, cause no spalling or deformation of Rollway Bearings.

1,122,000 Pounds Ride on 68 Rollway Bearings

One of the largest in the world, this 500-ton Morgan-built ladle crane is Rollway equipped in many positions.

Sixty-eight maximum-type, solid-cylindrical bearings—mounted without inner races—lift and lower the 1,122,000-pound weight of the lifting beam, ladle hooks, ladle and white-hot steel.

Rollway Tru-Rol® type bearings are used in the two General Electric 360 HP – MD-620 Hoist motors which lift the weight of the ladle and its molten metal content.

The maximum-type bearings in the hoisting sheaves are mounted directly on the shaft without inner races, which greatly simplifies assembly for applications of this size.

Thrust bearings in the 25-ton and 75-ton auxiliary crane hooks are standard Rollway precision types with broad-area contact between rollers and plates to prevent Brinelling and assure freedom of rotation under the heaviest loads.

Sheaves ready for assembly on shaft and installation in lifting beam.

For bearings that accomplish the extraordinary in an ordinary manner, write, wire or 'phone Rollway Bearing Co., Syracuse 1, N.Y.

ROLLWAY® BEARINGS

ENGINEERING OFFICES: Syracuse • Boston • Chicago • Detroit • Toronto • Pittsburgh • Cleveland • Seattle • Houston • Philadelphia • Los Angeles • San Francisco

Need Infinite Speed Adjustment—Accurate Control?

Get Both with

DYNAMATIC®

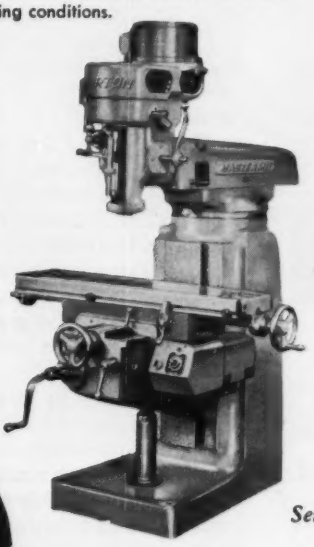
FRACTIONAL HORSEPOWER AJUSTO-SPEDE® DRIVES

Parker Majestic No. 2 Universal Grinder is equipped with two Ajusto-Spede Drives. One drive, mounted on the headstock, rotates the work against the grinding wheel. Another drive operates the table feed. Both work speed and table speed are infinitely adjustable to suit varying conditions.

Wherever infinite adjustment and accurate control of speed are required for proper machine operation, satisfied users are realizing improved machine performance and product quality through the use of Dynamatic Ajusto-Spede Drives. Stepless adjustment from zero to full output speed, and accurate control of any speed within the range, permit operation at the exact speeds required.

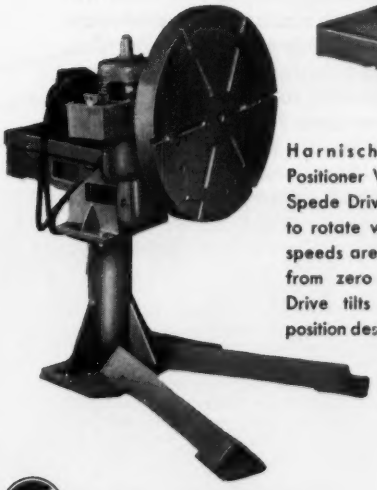
Ajusto-Spede Drives operate on standard 115/220 volt alternating current, requiring no special power source. The compact drive with its integral control system needs no wall space, and requires little space on the driven machine. These drives may be mounted in any position, providing great versatility of application. Twelve models are available in ratings from ¼ hp at 1650 rpm through 1 hp at 3200 rpm.

Before you specify a fractional horsepower drive for your product or plant equipment, check the many advantages offered in the Dynamatic Ajusto-Spede Drive.

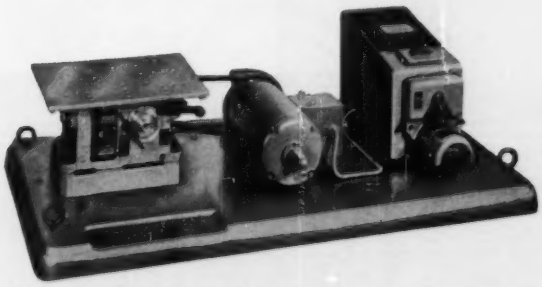


A Dynamatic Ajusto-Spede Drive provides infinitely adjustable table feed speeds on a Gorton Mastermil. Stepless adjustment permits the operator to select the proper table speed for maximum efficiency in machining all metals.

Send for Your Free Copy of Illustrated Bulletin FAS-6 which Describes Dynamatic Ajusto-Spede Drives



Harnischfeger Welding Positioner WP-1 uses an Ajusto-Spede Drive and gear reducer to rotate welding table. Table speeds are infinitely adjustable from zero rpm to 4.47 rpm. Drive tilts with table to the position desired by the operator.

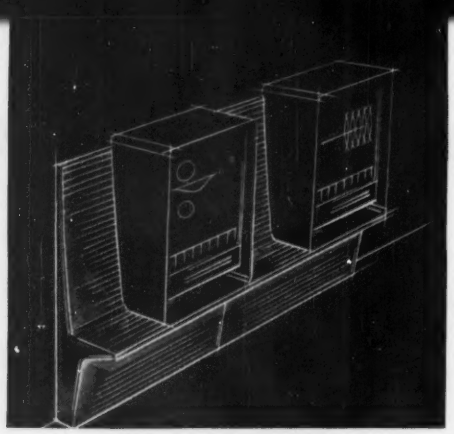


Vibration Fatigue Testing Machine manufactured by the All American Tool and Mfg. Company employs an Ajusto-Spede Drive to operate a vibrating table at various speeds for testing instruments and electrical components.

EATON

EATON

DYNAMATIC DIVISION
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE • KENOSHA, WISCONSIN



SHARONART*

a new idea in steel . . . sparks a new idea in

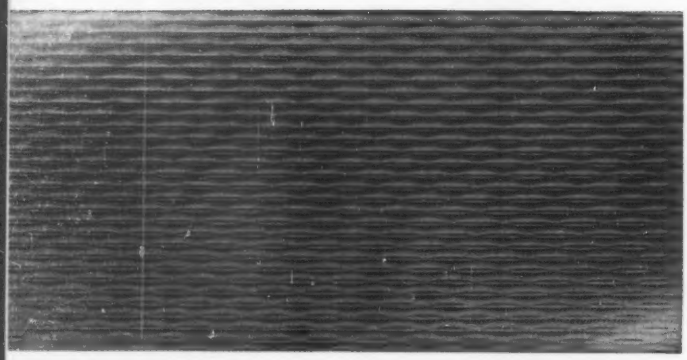
Famed designer Peter Schladermundt creates new machine concept using New Sharon Steel.

Vending machines can now stay brighter, newer, longer . . . thanks to amazing new Sharonart*.

Believing few machines are subject to the abuse received daily by the vending machine, nationally famous designer Peter Schladermundt recognized the many advantages Sharonart* would impart to this hard working equipment.

Sharonart* is patterned steel at its finest . . . and the many pattern combinations present a new plateau for the machine designer. He can now make model changes simply by altering steel patterns. But more important, Sharonart* resists marking and now vending machines will be able to absorb much more punishment without losing their attractiveness. Too, with modern painting techniques, manufacturers are able to achieve smart, new color combinations to give their product even greater beauty and sales appeal.

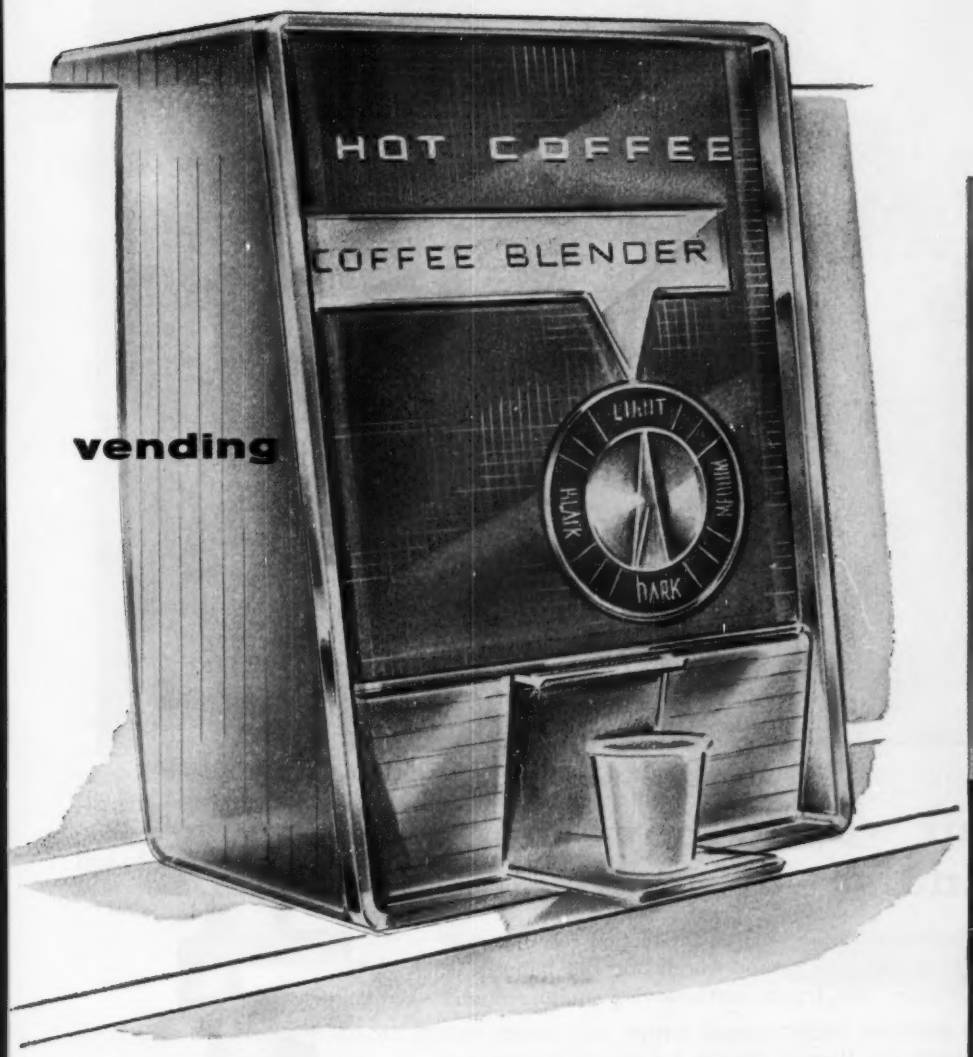
Wherever functional beauty and long life are desired, Sharonart* is the one perfect metal. For additional information write Sharonart, *Sharon Steel Corporation, Sharon, Pa.*



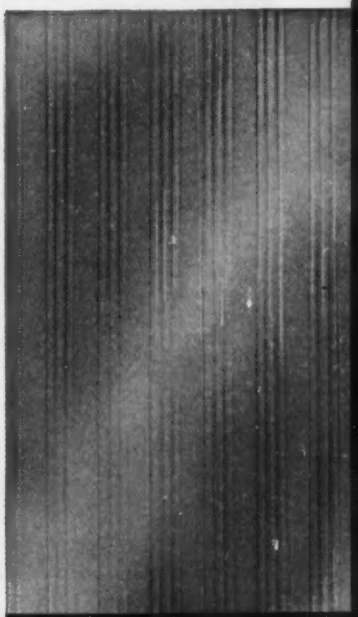
Aside from designing the vending machine of Sharonart, Peter Schladermundt has created an entire new process of machine vending. By developing special racks, machines can be easily added and removed according to demand, and/or for refilling. Rack could be made as a fixed wall type, or as an island, with machines operated from both sides. Machines could be hung individually or doubly, saddle style.*

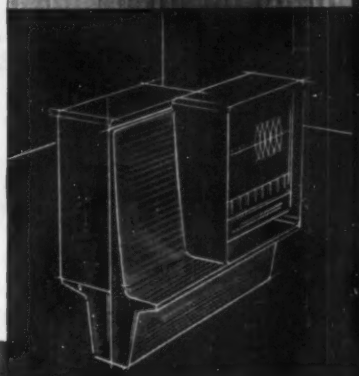
Note: The vending machine idea illustrated on these pages is not now a manufactured product. It is a design only. *TM

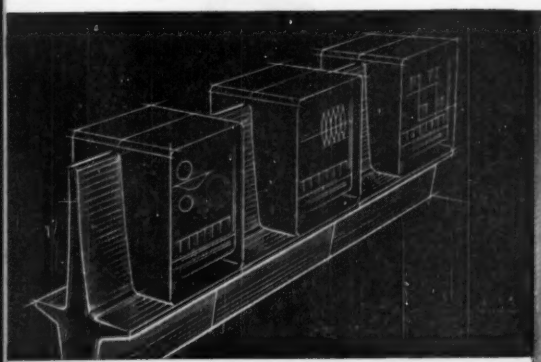
SHARON *Quality* **STEEL**

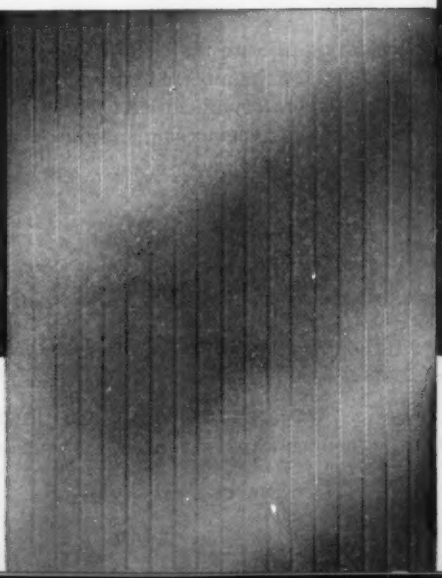


vending









SHARONSTEEL

Circle 466 on Page 19

On their way to move men, merchandise—or mountains

For a nation on wheels and on the wing—a production run of forged crankshafts and jet engine compressor wheels for the builders of power-plants for pleasure cars, trucks, earth-moving equipment, and aircraft.

In missile development, too, Wyman-Gordon has proved the value of forging in achieving the highest strength-weight ratios, at elevated temperatures.

With forging experience dating prior to the birth of the internal combustion engine; with the greatest hammer and press capacity in the country; with unexcelled laboratory facilities; Wyman-Gordon is anxious to serve you at the design, engineering and purchasing stages of your developments.

EST. 1883

WYMAN-GORDON

FORGINGS

of Aluminum Magnesium Steel Titanium . . . and Beryllium Molybdenum Columbium and other uncommon materials

HARVEY ILLINOIS — WORCESTER MASSACHUSETTS — DETROIT MICHIGAN

GRAFTON MASSACHUSETTS — FRANKLIN PARK ILLINOIS — LOS ANGELES CALIFORNIA — FORT WORTH TEXAS

Circle 467 on Page 19

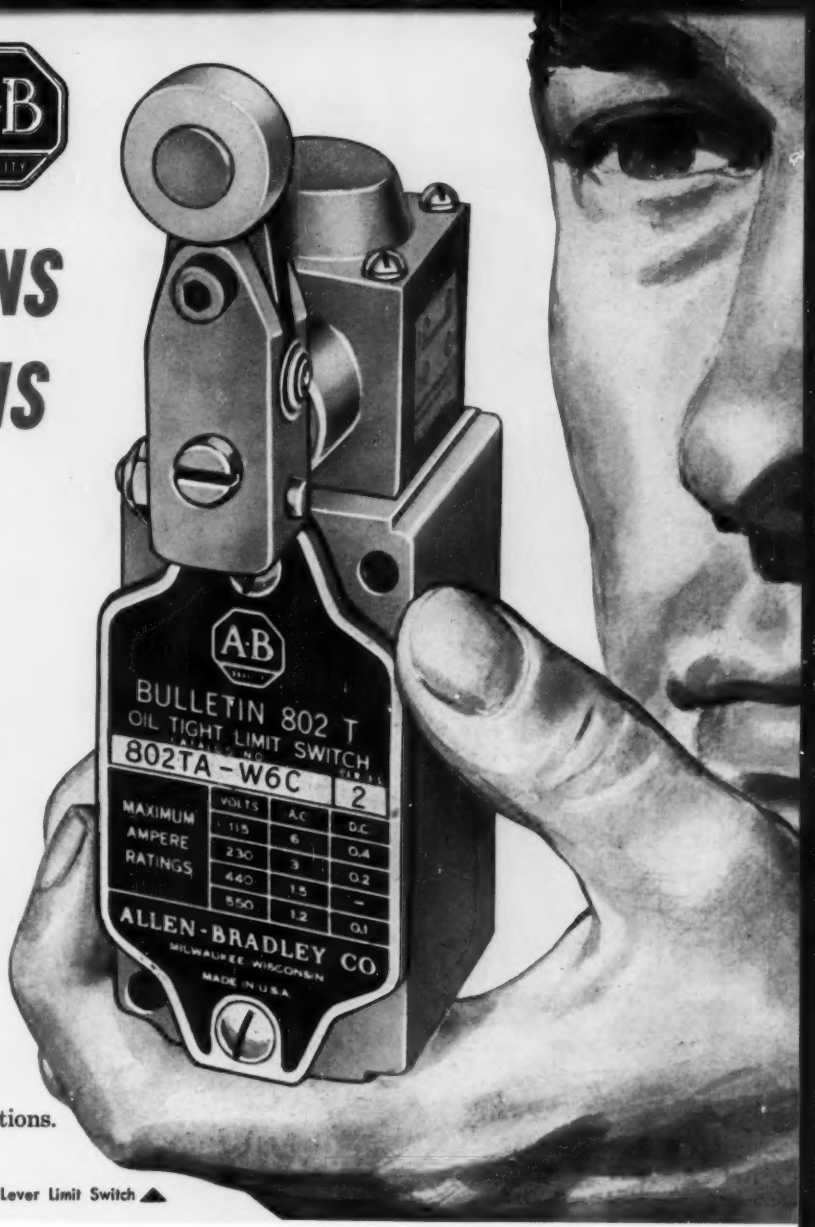
Circle 468 on Page 19→

MORE MILLIONS OF OPERATIONS

with Allen-Bradley Limit Switches

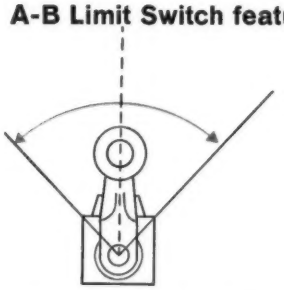
There's nothing now on the market to match the reliability and trouble free performance of Allen-Bradley Bulletin 802T limit switches. They are completely oiltight—operating heads and switch bodies are sealed against oils, coolants, and metal chips. Operators cannot become sluggish or "stick" in operation—contacts cannot become fouled. The double break, silver contacts are always in perfect operating condition—and remain so without maintenance.

Insist on Allen-Bradley—the *quality* line of limit switches that will give you *many more millions* of trouble free operations.

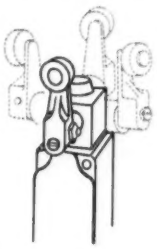


Bulletin 802T Micrometer Adjustment Roller Lever Limit Switch ▲

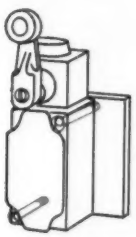
A-B Limit Switch features mean more life, more dependable trouble free service

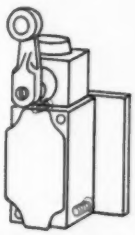


REPETITIVE ACCURACY—Unique toggle blade action assures operation at precisely the same point each time, without adjustment.



FLEXIBILITY—All operating heads can be rotated and fastened in any of four positions 90° apart.





FRONT MOUNTING **REAR MOUNTING**

All Allen-Bradley Limit Switches can be mounted either from the front . . . or from the rear.

SEE OTHER SIDE FOR TYPICAL APPLICATIONS ⟶

1-60-MR

ALLEN-BRADLEY

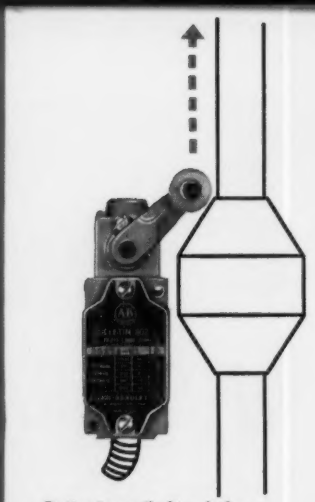
Member of NEMA

Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis. • In Canada: Allen-Bradley Canada Ltd., Galt, Ont.

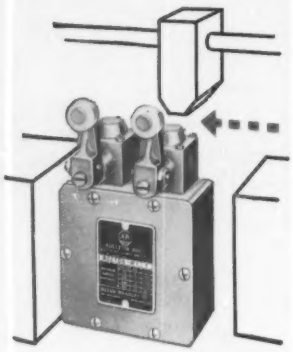
QUALITY MOTOR CONTROL

Allen-Bradley has an Oiltight Limit Switch to meet your exact needs!

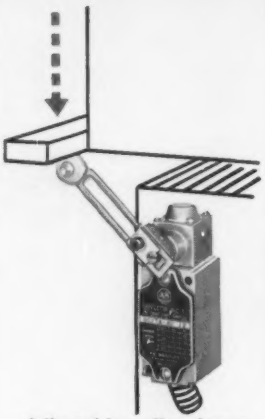
From among the wide variety of Allen-Bradley oiltight limit switches, you are certain to find the exact type to satisfy your specific requirements. If you do not, then please discuss *your* problem with us. A-B limit switches are available with many different levers, lever-contact actions, operating forces, and actuator motions—in spring return or maintained contact construction. A new 16-page illustrated booklet on this *quality* line of A-B oiltight limit switches is just off the press. Write for it!



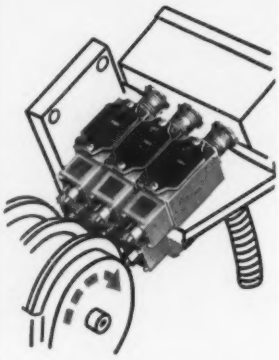
Roller lever limit switch—Here it is operated by dog on vertically moving shaft.



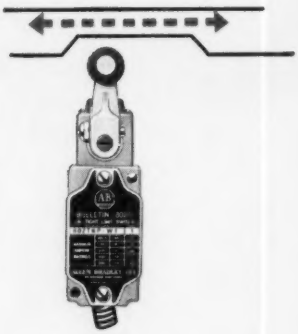
Duplex limit switch where block can also trip second switch for safety insurance.



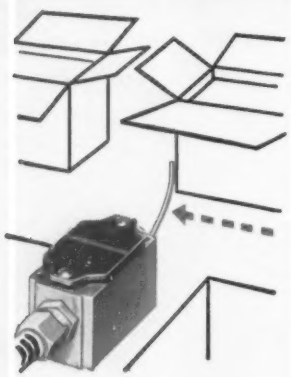
Adjustable roller lever switch. Lever set for operation at greater than normal distance.



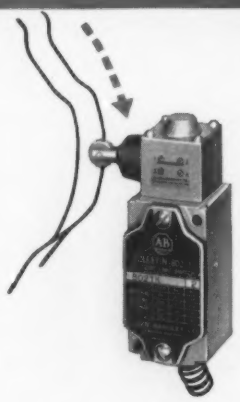
Top push roller limit switches are frequently operated by rotating cams on machine tools.



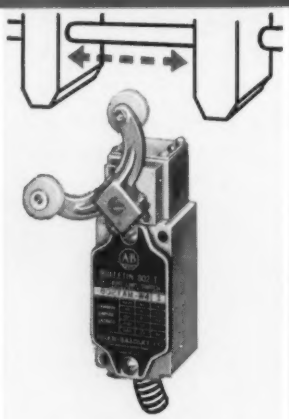
Neutral position switch—moving bar closes separate contacts as it moves each way.



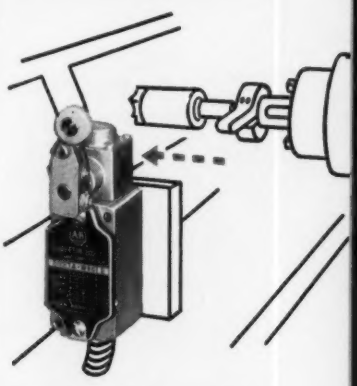
Cat's whisker limit switch is actuated by movement of lightweight units on conveyor.



Side roller limit switch, as illustrated here, is being actuated by a rotating cam.



Fork lever maintained contact switch—adjustable dogs trip one roller in each direction.



Micrometer adjustment switch for precise setting of trip point in machine tool operations.

1-60-MR

ALLEN-BRADLEY

QUALITY MOTOR CONTROL

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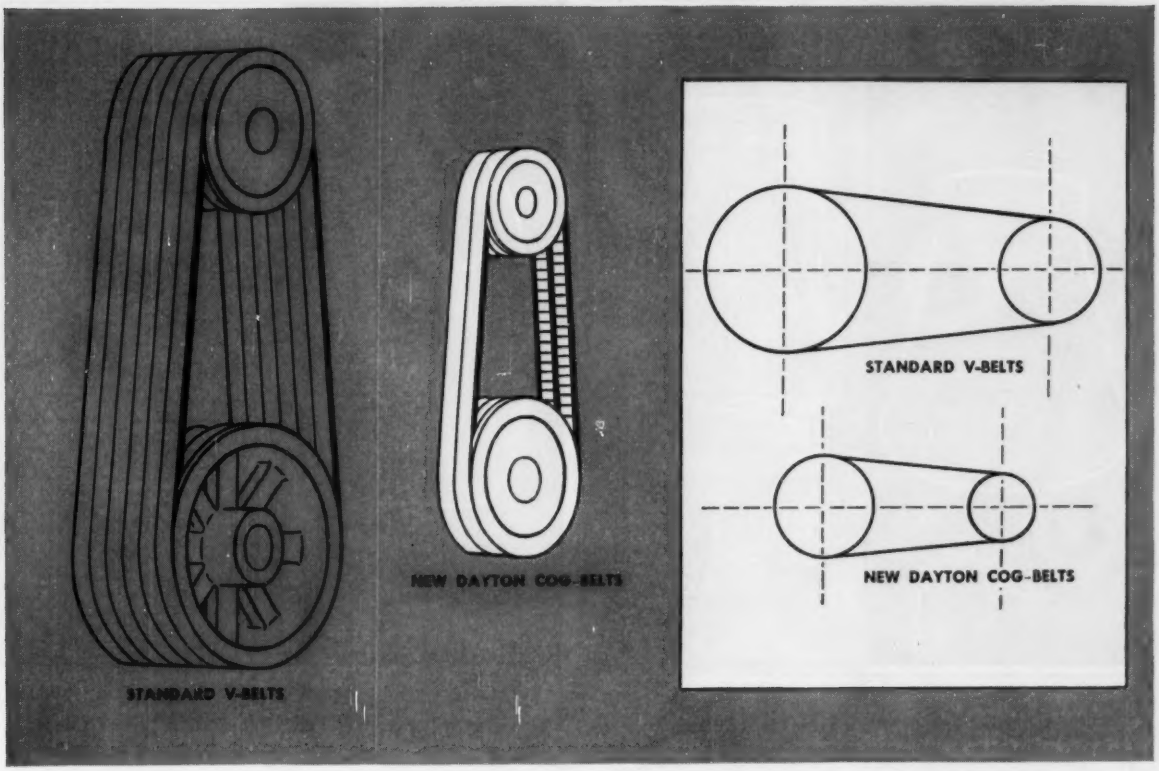
Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada: Allen-Bradley Canada Ltd., Galt, Ont.



Up to 300% higher H. P. Rating for **Dayton** *Cog-Belts®* *reveals* **New Design Advantages**

Now, possibilities are virtually unlimited for the development of advanced power transmission systems and the improvement of present designs. Dayton's top horsepower rating and superior strength offer these outstanding advantages:

1. **Two Cog-Belts can now do the job of six standard V-Belts . . .** and do it better. Sheave width can be reduced 67%.
2. **Sheave diameters and center distances can be reduced as much as 30%** due to the extreme flexibility built into the Dayton Cog-Belt.
3. **Final weight of drives and production costs can be reduced 40% or more.**

Actual on-the-job testing, under the most rugged conditions possible, has proven time and again that Dayton Cog-Belts are unequalled for performance and dependability . . . outlasting other quality belts by as much as 4 to 1. Their extreme flexibility and resistance to oil, heat and static build-up make them ideal for use on high speed drives, or with sub-standard sheave diameters or where oil and heat are factors.

Dayton's exclusive molded raw-edge construction provides tremendous gripping power. Permits operation less tension, resulting in increased bearing life. No special sheaves necessary.

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Send today for your free copy of the engineer's "Handbook of V-Belt Drive Design and Selection." It will prove to be a "treasure chest" of *new* ideas.

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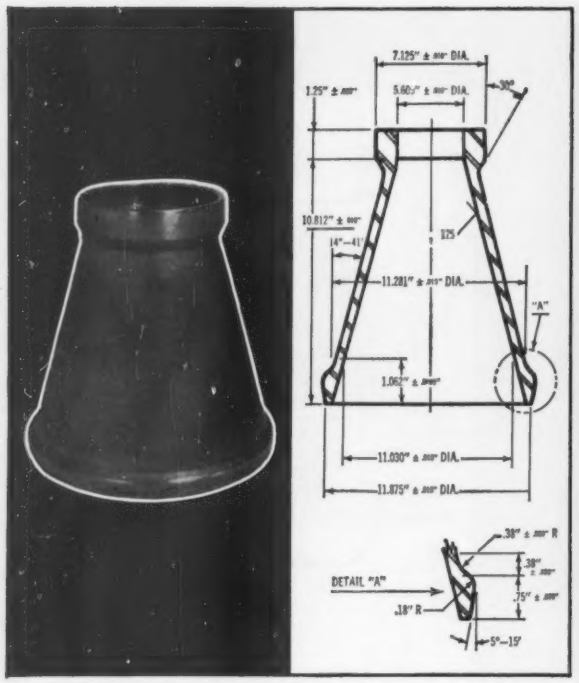
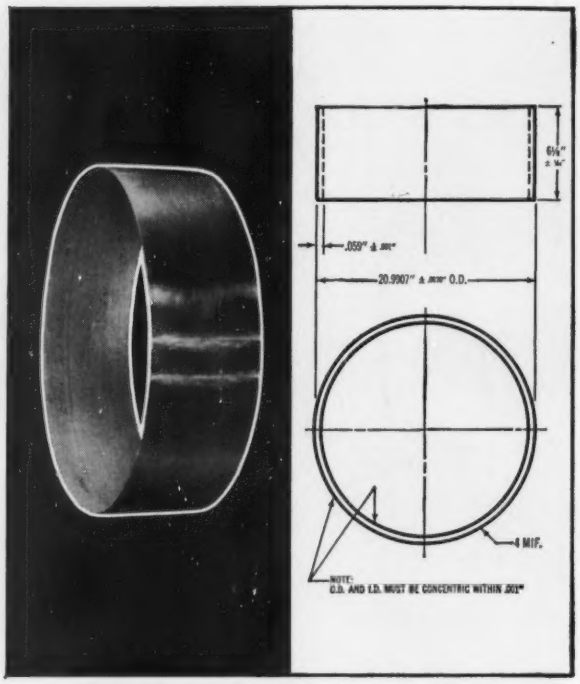
COMPANY_____
TITLE_____
ADDRESS_____
CITY_____ ZONE_____ STATE_____

←Circle 468 on Page 19

Circle 469 on Page 19



STRAIGHT SIDE ROCKET CONE—Spun with tapered wall from 1020 steel blank: 18" diameter, 1" thick. Inside surface 125 MIF.



STRAIGHT WALL TUBE PRINTING BAND—Spun from ⅛" thick aluminum to .060" wall thickness, outside surface machine finished to 4MIF.

ROTOFORMS open new

ROTOFORMING reduces cost of unusual metal shapes—saves metal, eliminates machining and surface finishing

The design possibilities for hollow metal shapes are now unlimited. The most unusual metal custom parts can be practically and economically produced by ROTOFORMING.

This revolutionary new metal forming service now being offered by COMMERCIAL SHEARING & STAMPING displaces metal in a blank or preform. Rollers contacting the outside surface of the metal form it by high pressure as it rotates around a mandrel. The shape of the mandrel itself, at all times, controls the inside contour and size of the part.

WHAT SHAPES ARE POSSIBLE? Basically, ROTOFORMS can be grouped into four main categories: Straight-Side Cones, Straight-Wall Tubes, Curvilinear-Wall Shapes, and Elliptical or Hemispherical Shapes. Pictured above are representative ROTOFORMS already produced by COMMERCIAL. Principal dimensions are included.

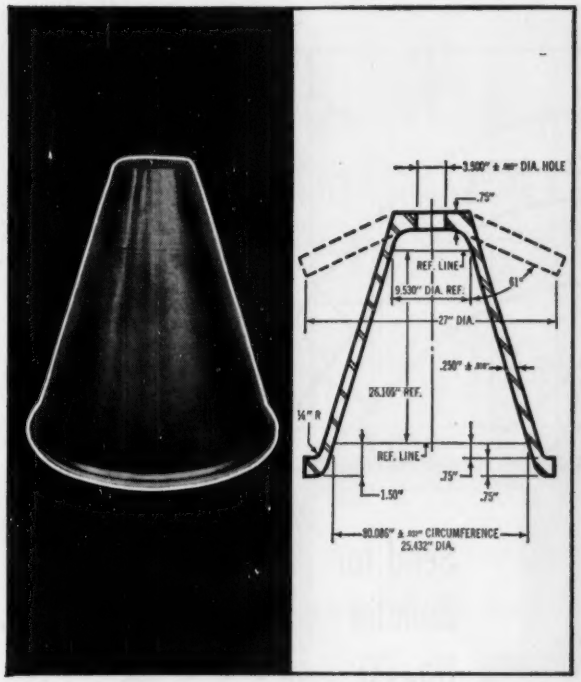
WHAT ABOUT SIZE AND WALL THICKNESS? The range of sizes for ROTOFORMS covers maximum diameters up to 42" down to a minimum tube I.D. of 2¼". Tube length can go as high as 100".

Steel blanks up to ¾" thick can be successfully handled by ROTOFORMING where conical shapes are involved. And when it comes to forming straight-wall tubes the wall thickness of steel blanks can even go up to ⅝". When forming metals more ductile than steel it is possible to work blanks with even greater wall thicknesses than those above.

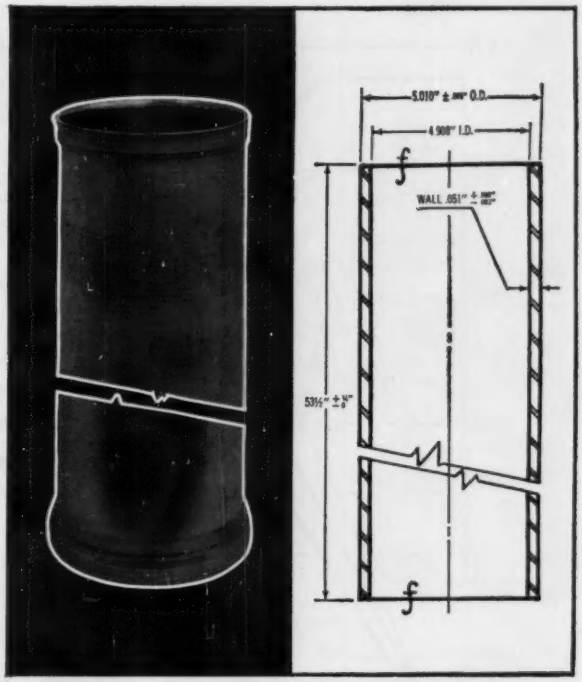
With ROTOFORMS wall thicknesses—both constant and variable—are feasible. Walls referenced to C/L can be straight, curved, or tapered. And ROTOFORMS have been successfully produced with a finished wall thickness no greater than $\frac{1}{32}$".

WHAT METALS CAN BE ROTOFORMED? A wide variety of carbon steels, stainless and special alloy steels, as well as aluminum, nickel, copper, molybdenum, magnesium and titanium alloys can be successfully ROTOFORMED. Even metal alloys such as 4130 steel, 1100-0 aluminum, and hard to machine Hastelloy, can and are being used in the regular production of ROTOFORMS.

WHAT HAPPENS TO THE METAL? The plastic deformation which metals undergo in the ROTOFORMING process elongates their grain structure and sub-



STRAIGHT SIDE MISSILE EXIT CONE—Spun with constant wall thickness from press pre-formed 1040 steel blank: 29" diameter, ¾" thick.



STRAIGHT WALL ROCKET TUBE—Spun from 4135 steel tubing (wall thickness ½") reduced to finished wall .051".

horizons for metal shape design!

stantially increases their strength. Tensile increases 1½ to 2 times, yield point is raised in even higher proportion, and fatigue strength is substantially improved. And ROTOFORMED parts can be heat treated to increase their ductility.

Because of the plastic deformation of metal, involved weld joints become unnoticeable when ROTOFORMED. And there are no hidden metal flaws in ROTOFORMS. Any metal inclusions or flaws in the parent metal are quickly uncovered during the ROTOFORMING process—appear as ruptures when pressure spinning rolls reposition the metal by physical displacement. Only 100% sound metal will produce successful ROTOFORMS.

WHAT ABOUT TOLERANCES AND FINISHES? Extremely close tolerances and tolerances commonly associated with fine machining are routine in the production of ROTOFORMS. It is not uncommon for ROTOFORMED parts taken from the machine as is to have inside diameters held to tolerances of +.000" −.003", +.005" −.000", and +.005" −.005".

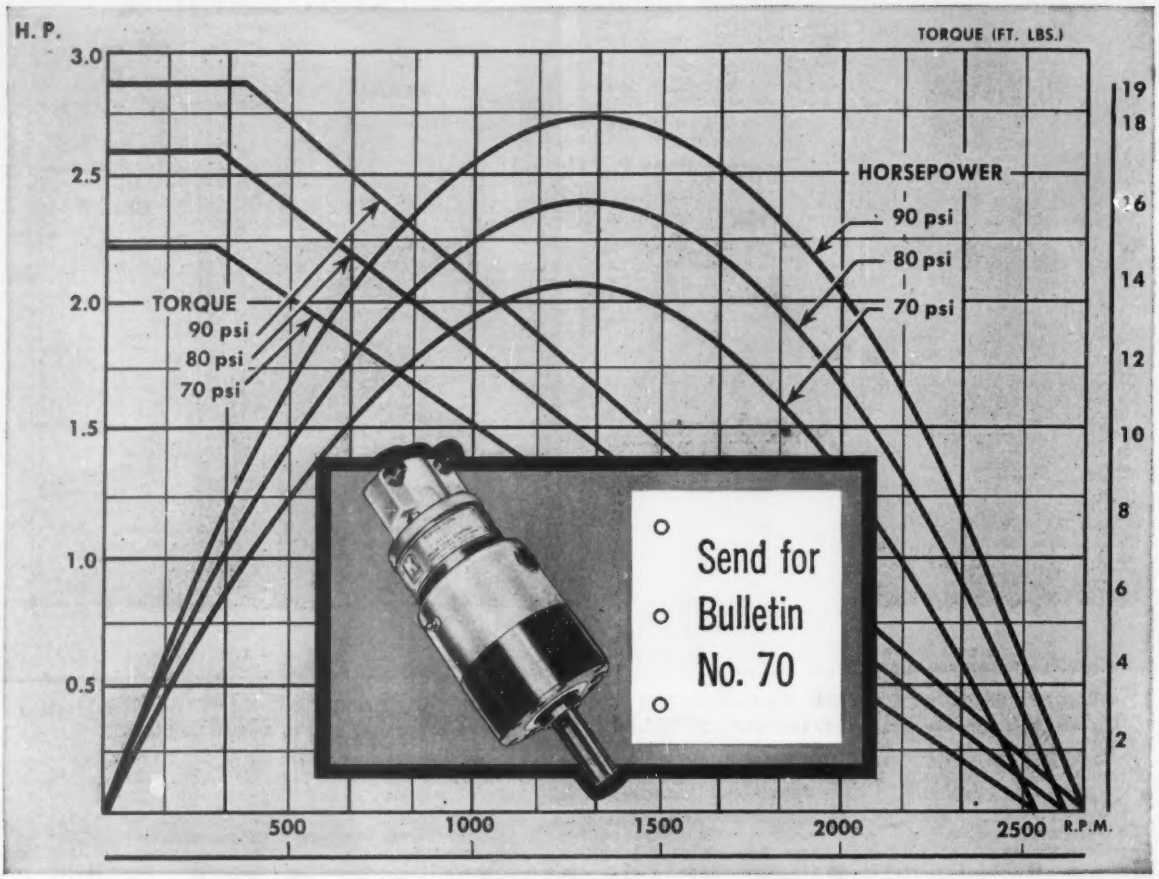
Inside areas of ROTOFORMS finish to a glass-like surface—30 to 60 micro inch finishes being well within standard production practice. While outside surfaces finish to about 125 micro inch.

Because dimensional tolerances and inside surface finish have a direct relation to the variation and finish of blank from which the ROTOFORM is produced, when necessary the tolerances of a blank can be reduced and its finish improved beforehand in order to provide closer tolerances and a better inside finish in the actual ROTOFORM. In addition, the outside surfaces of ROTOFORMS can be brought to smoother finish by grinding, polishing or fine machining.

AN INVITATION FROM COMMERCIAL! This new metal forming process could be the practical and economical answer to your particular component problem. You can find out very quickly. Just a blueprint, sketch or prototype of your part in the hands of our engineers will bring you the complete cost-saving story—and at no obligation. Address inquiries to Commercial Shearing & Stamping Co., Dept. S-4, Youngstown 1, Ohio.

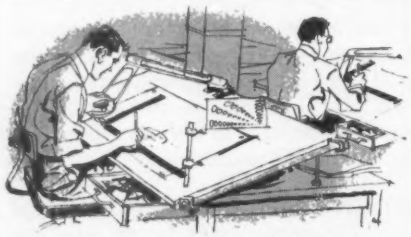
COMMERCIAL
shearing & stamping

Circle 470 on Page 19



Typical performance curves for one size of Gardner-Denver axial piston air motors.

Efficient operation at high or low pressure . . . Gardner-Denver axial piston air motor



WHEN YOU NEED A "SPECIAL"

. . . talk to the Gardner-Denver man—a specialist himself. He can help you design applications, special mountings, special controls. He'll see that your "special" is quality-engineered by experienced Gardner-Denver men, for there's no substitute for men—our 100-year philosophy of growth.

Here's a rugged, compact axial piston air motor from Gardner-Denver that operates efficiently whether air pressure is high or low. Therefore, it can be applied to low-speed, high-speed or infinitely variable speed drives—simply by regulating air supply. Sizes from 0.6 to 2.7 hp, with free speeds from 450 to 4800 rpm, stall torques to 110 ft.-lb.

Compact design permits use in places where space is limited. Stout spindle, tough bearings and rugged case give this air motor the ability to carry an overhung load as great as 1000 lb. with no external support. Rugged construction and precision parts insure maximum service with minimum maintenance. Can be mounted in any position.

This Gardner-Denver air motor also features instant starts and stops, reversible operation and no spark hazard. It works in heat, moisture or dust . . . can't burn out. Can air power help *your* design? For complete information, contact your nearby Gardner-Denver representative or write for Bulletin 70-1.

EQUIPMENT TODAY FOR THE CHALLENGE OF TOMORROW

GARDNER-DENVER

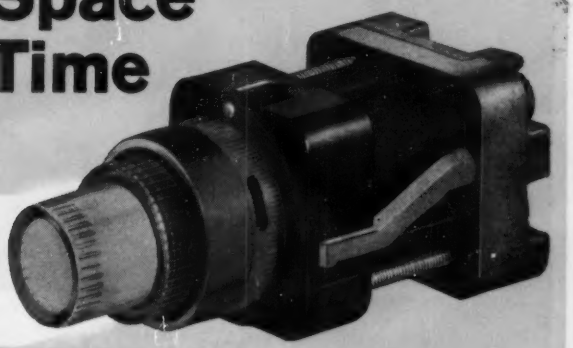
Gardner-Denver Company, Quincy, Illinois

In Canada: Gardner-Denver Company (Canada), Ltd., 14 Curity Avenue, Toronto 16, Ontario

Circle 471 on Page 19

...design leadership

Save Mounting Space and Installation Time *with this...*

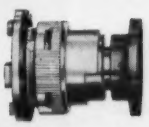


ILLUMINATED PUSH BUTTON

- Push button and pilot light combined in one compact, oil-tight device
- Full heavy-duty contact rating
- Pressure connections eliminate internal wires
- Clearly marked terminals for easy wiring
- Button guard available to prevent accidental operation
- Full range of voltage ratings
- Choice of 6 color caps
- Same single-hole mounting as other oil-tight units

A *Complete* LINE OF OIL-TIGHT CONTROL UNITS

Standard Button

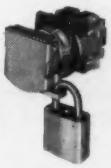

Mushroom Button

Selector Switch

Coin-operated Selector Switch

Key-operated Selector Switch

Stop Button Lockout

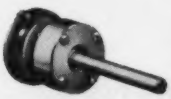

Start Button Lockout

Maintained Contact Attachment

Push-to-Test Pilot Light

Selector Switch Padlock Attachment

Selector Switch with Gloved Hand Operator

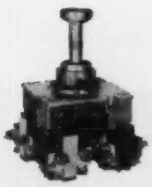

Wobble Stick Operator

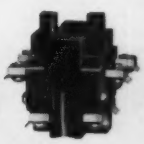
Extended Guard Button

Pilot Light

Selector-Push Button

Neoprene Cap


4-Position Joystick Operator


Wide Range of Contact Blocks

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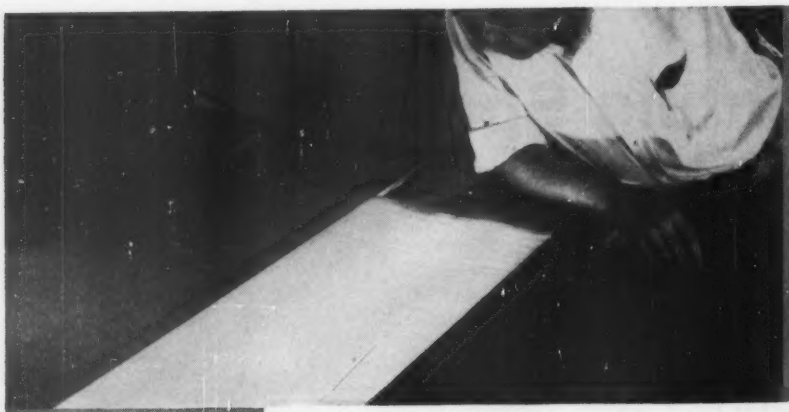

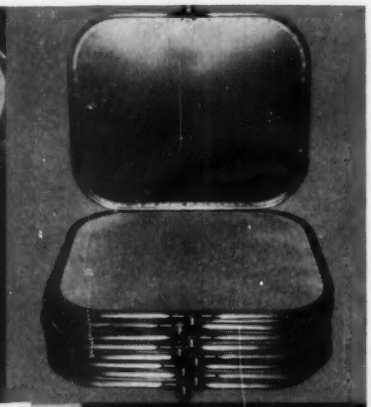

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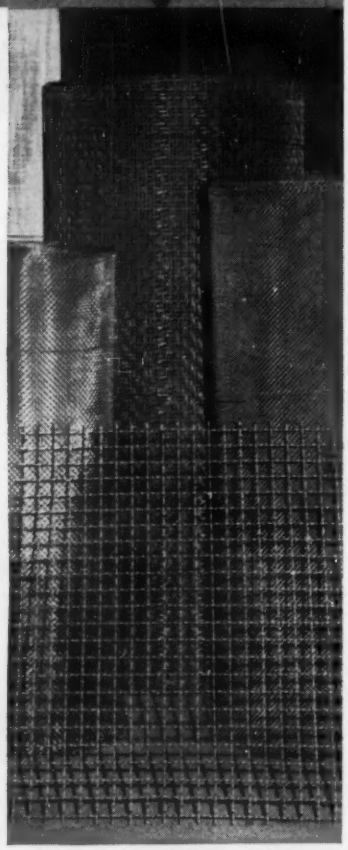
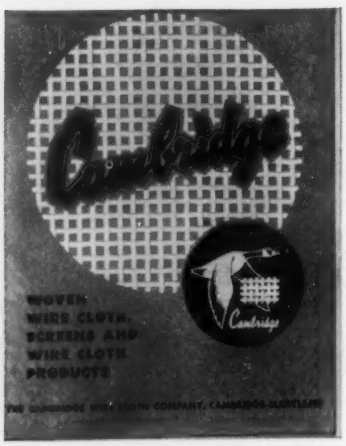
Manufacturers of Wire Cloth, Metal-Mesh Conveyor Belts, Wire Cloth Fabrications





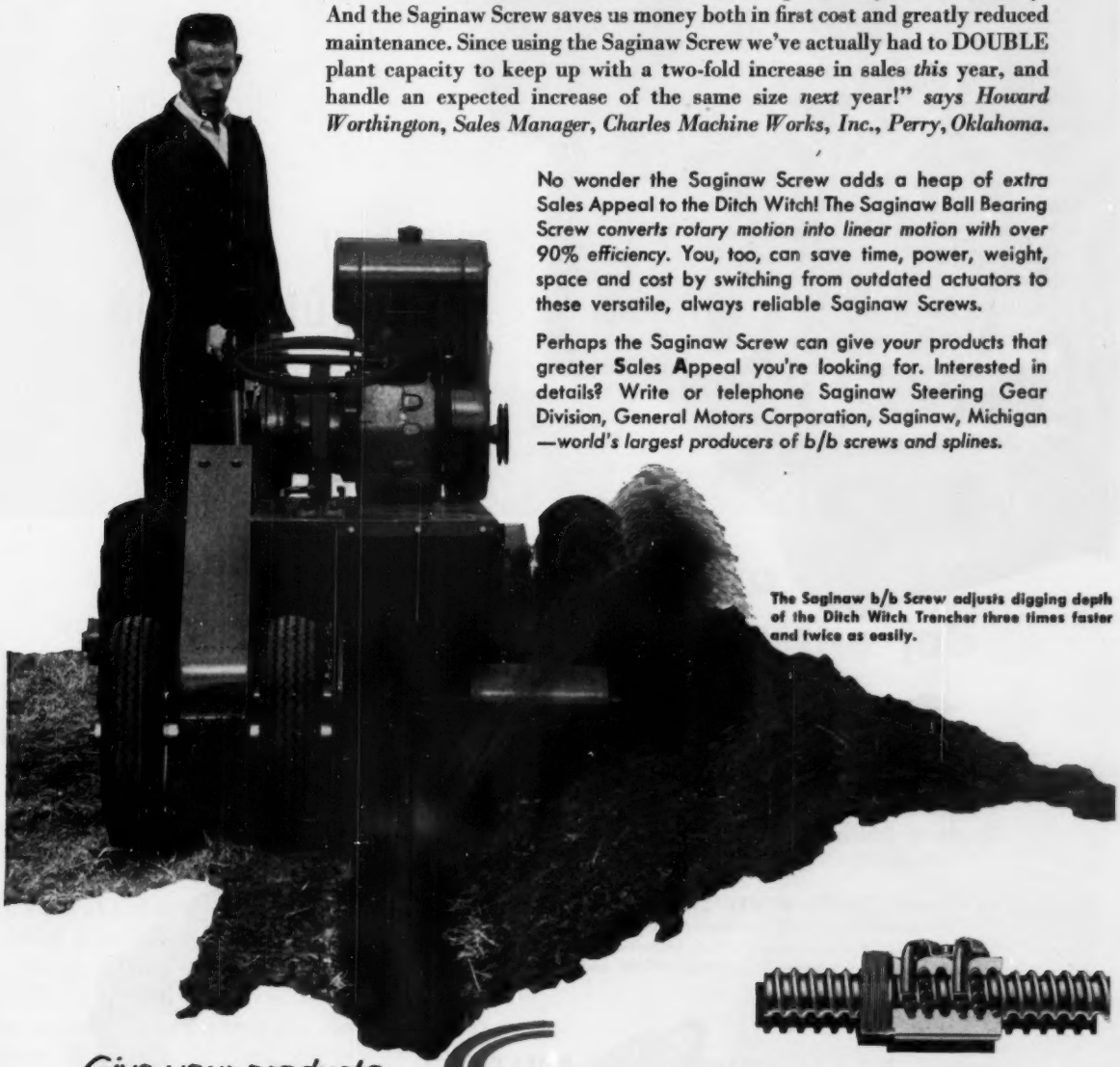
the SAGINAW b/b SCREW helps

Double Ditch Witch Sales in One Year!

"We've replaced an acme screw with a Saginaw Ball Bearing Screw to enable the digging boom of our Ditch Witch Trench Digging machine to be raised and lowered three times faster. It makes the operator's job twice as easy. And the Saginaw Screw saves us money both in first cost and greatly reduced maintenance. Since using the Saginaw Screw we've actually had to DOUBLE plant capacity to keep up with a two-fold increase in sales *this* year, and handle an expected increase of the same size *next* year!" *says Howard Worthington, Sales Manager, Charles Machine Works, Inc., Perry, Oklahoma.*

No wonder the Saginaw Screw adds a heap of *extra* Sales Appeal to the Ditch Witch! The Saginaw Ball Bearing Screw *converts rotary motion into linear motion with over 90% efficiency.* You, too, can save time, power, weight, space and cost by switching from outdated actuators to these versatile, always reliable Saginaw Screws.

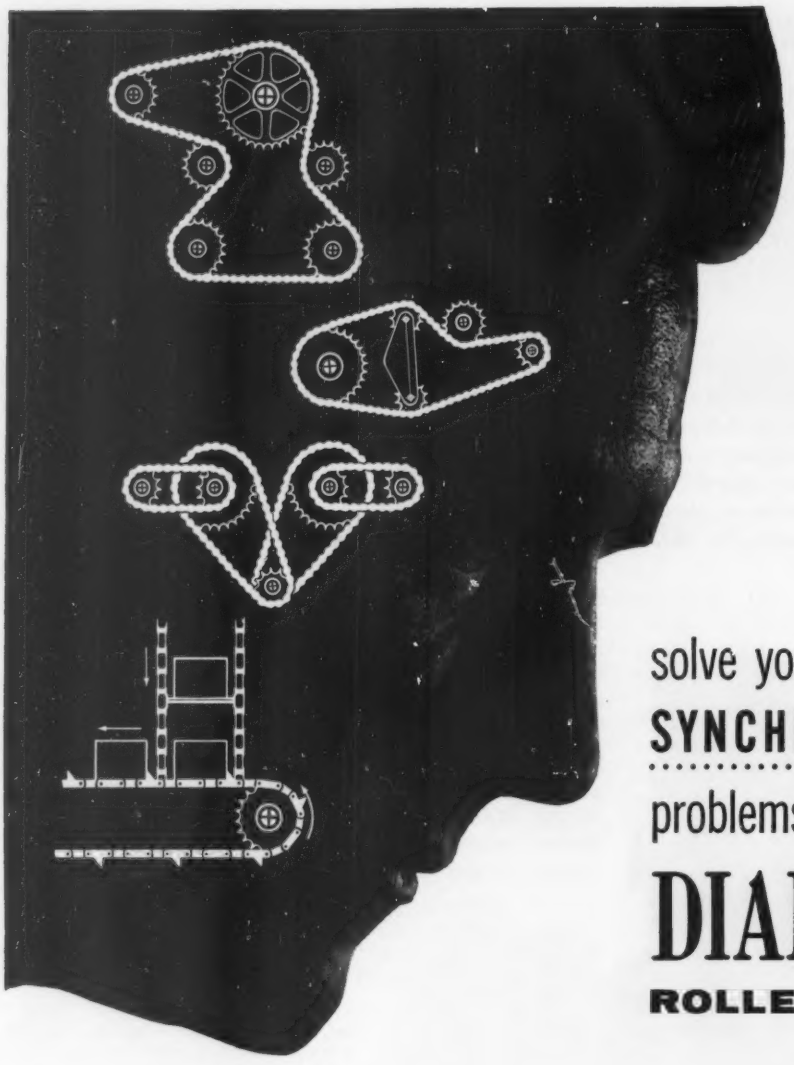
Perhaps the Saginaw Screw can give *your* products that greater **S**ales **A**ppeal you're looking for. Interested in details? Write or telephone Saginaw Steering Gear Division, General Motors Corporation, Saginaw, Michigan —*world's largest producers of b/b screws and splines.*



The Saginaw b/b Screw adjusts digging depth of the Ditch Witch Trencher three times faster and twice as easily.

Give your products NEW SALES APPEAL... switch to the **Saginaw** **b/b ball bearing Screw**

WORLD'S MOST EFFICIENT ACTUATION DEVICE



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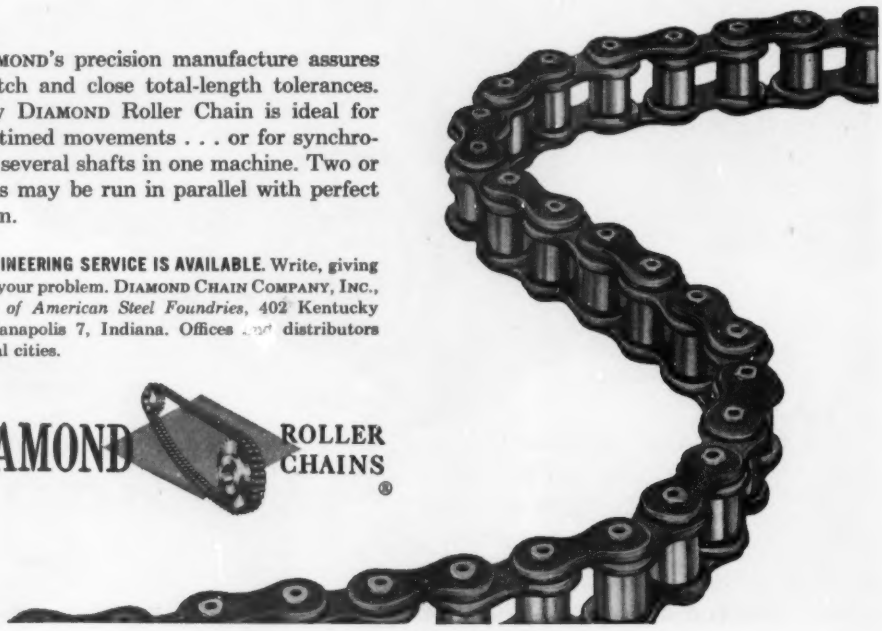
ROLLER CHAIN

DIAMOND's precision manufacture assures uniform pitch and close total-length tolerances. That's why DIAMOND Roller Chain is ideal for accurately timed movements . . . or for synchronization of several shafts in one machine. Two or more chains may be run in parallel with perfect coordination.

DIAMOND ENGINEERING SERVICE IS AVAILABLE. Write, giving full details of your problem. DIAMOND CHAIN COMPANY, INC., *A Subsidiary of American Steel Foundries*, 402 Kentucky Avenue, Indianapolis 7, Indiana. Offices and distributors in all principal cities.



DIAMOND ROLLER CHAINS ®

Simplest, surest way to a "thousandth" fit . . . right at the job

What you see here is a shim. Not an ordinary shim, but a shim of LAMINUM—and that's what makes the difference in convenience, accuracy, speed and economy.

LAMINUM is the registered trade name for the laminated shims whose layers are completely surface-bonded to look and act like solid metal. Yet the laminations are easily p-e-e-l-e-d to bring the shim to any desired thickness for an individual, perfect fit, right at the assembly line.

No stand-by equipment. No machining. No grinding. No counting. No stacking or miking. And no grit between layers —ever. *That's* what saves time! And cuts costs!

Shims of LAMINUM are economically custom-made to your specifications. In brass, mild steel, stainless and aluminum, with laminations of .002″ or .003″. For quick service, send your inquiries for information or estimates directly to . . .

THE LAMINATED SHIM COMPANY, INC.

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Circle 475 on Page 19

GET THE FACTS

Write for SHIM DESIGN Folder No. 3—eight pages of up-to-date, well illustrated design information and specifications.

HOW CAN NICE HELP YOU?

NICE offers...

. . . complete lines of precision, semi-precision and unground standard bearings.

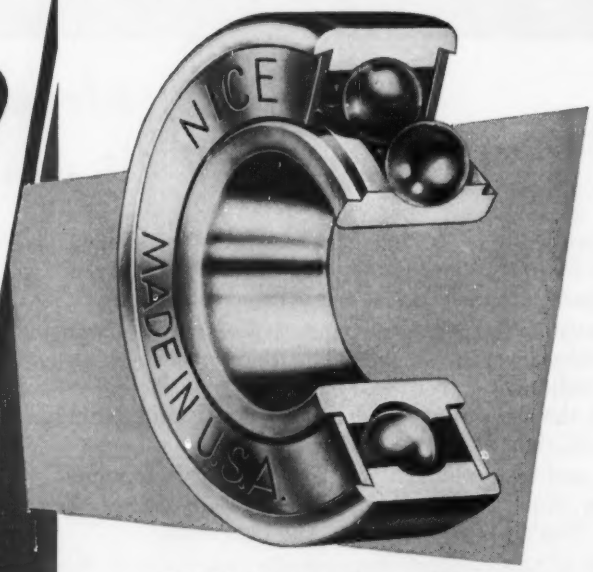
. . . facilities and "know-how" to design and produce "specials" to exactly suit individual bearing application requirements.

. . . standard and special bearings that offer Product Designers many design improvement and cost-saving opportunities.

. . . bearings that have proved their economic and performance value in the accepted products of many hundreds of well-known manufacturers.

. . . NOW . . . the revolutionary new UNIBAL, a low cost bearing of superior quality, suitable for many precision bearing applications. UNIBAL construction features solid inner and outer raceways, with deep, unbroken ball grooves and a full complement of balls. Unique new and patented manufacturing methods produce bearings of exceptional durability and strength.

How can NICE help YOU?



As illustrated above, the new UNIBAL Ball Bearing features solid inner and outer raceways, with deep, unbroken ball grooves, *plus* a full complement of balls.

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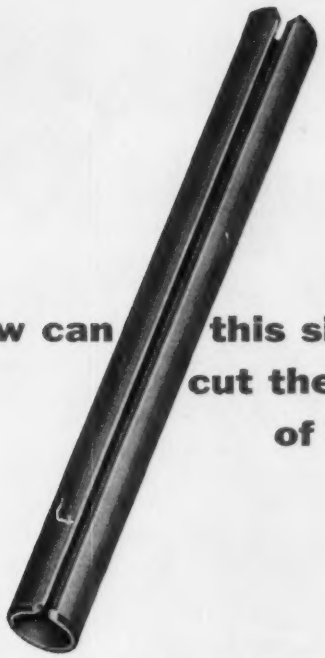
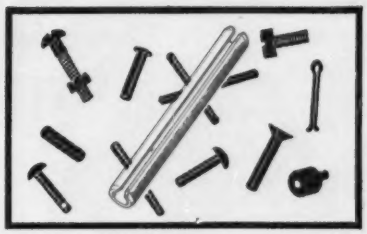


How can this simple fastener cut the cost of your product?

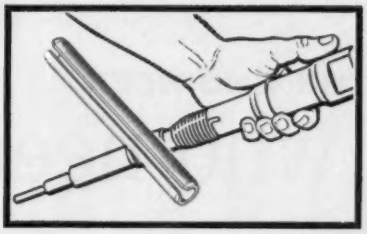
Rollpin aids standardization and reduces inventory

Rollpin readily replaces taper pins, grooved pins, straight pins and set screws; it can be used as a locating dowel, hinge pin, cotter pin, stop pin or, in some applications, even as a rivet. Thus, when you standardize on a Rollpin you can drastically reduce the variety of fasteners in your inventory—save money in purchasing, storage space and stock handling.



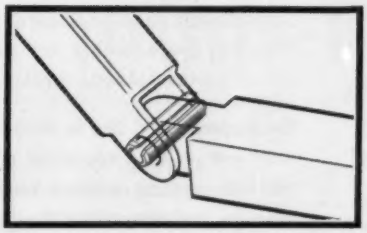
Rollpin simplifies production processing . . . saves man-hours

When you use Rollpin you can eliminate costly precision drilling, or tapping operations. And there's no need for any secondary locking operation—such as lock wiring or peening. That's because Rollpin is a slotted tubular steel spring whose chamfered ends drive easily into standard production-drilled holes, compressing as driven. The spring tension against the hole walls retains Rollpins securely against severe vibration. Independent studies have shown that installed costs of Rollpin are as much as *91% less* than those for a dowel pin or *95% less* than the installed cost of a taper pin.



Rollpin simplifies product maintenance

Only a drift pin or standard punch is required to remove a Rollpin. The slotted tubular shape and the spring action principle do not damage hole walls or enlarge the original hole diameter. Consequently the same pin is easily re-inserted and can be used again and again. Mail our coupon today for the complete Rollpin story.



ROLLPIN®

a product of
Elastic Stop Nut Corporation of America

Dept. R58-14, Elastic Stop Nut Corporation of America
2330 Vauxhall Road
Union, New Jersey

Please send the following free fastening information

- ☐ Rollpin bulletin
- ☐ ELASTIC STOP® nut bulletin
- ☐ Here is a sketch of a fastening problem. What ESNA® fastener would you recommend?

Name_____

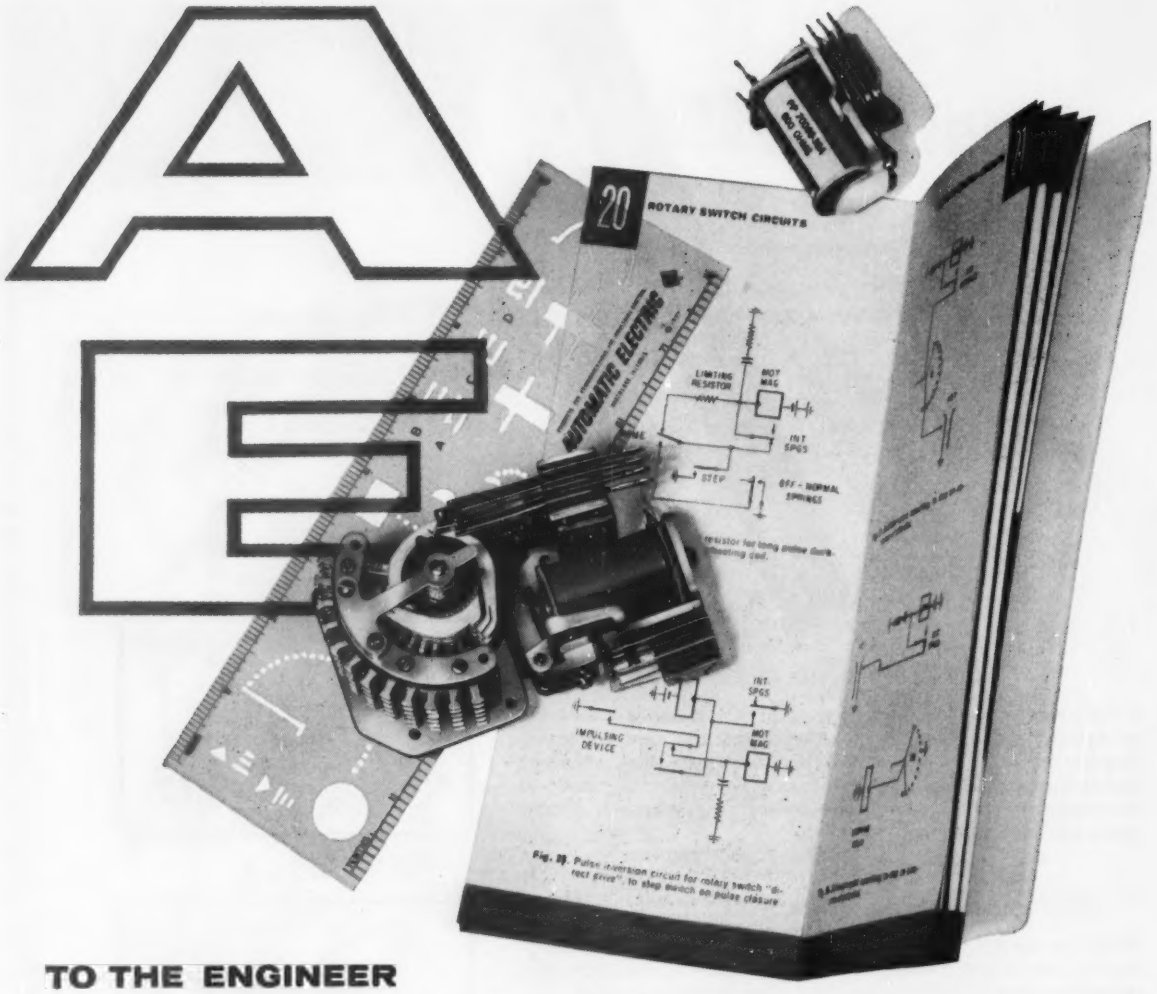
Title_____

Firm_____

Street_____

City_____ Zone____ State_____

Circle 477 on Page 19



TO THE ENGINEER

who needs "for instances"

Take such a "for instance" as this: you want to step an indirectly driven rotary switch immediately on pulse closure. The schematic, Fig. 28, above, points out an easy way of doing it with a standard relay.

Or suppose you'd like to stretch a pulse with a relay—or set up a sequential programming circuit with stepping switches. You'll find the most practical methods among the 41 schematics in AE's new 32-page booklet on "Basic Circuits." It comes complete with a handy template for drawing relays and switches on your own circuits. And it's all yours for the asking!

In case you don't find the solution to your switching problem in *Basic Circuits*, our engineers can find a solution for you. In fact, AE engineers can show you switching tricks that will cut corners on costs. Or, if you wish, they'll assume the job of designing and building to *your* specs, anything from a simple control package to an entire system.

To get your copy of *Basic Circuits* and/or the answer to your specific control problem, just write J. E. James, Director, Control Equipment Sales, Automatic Electric, Northlake, Ill. In Canada: Automatic Electric Sales (Canada) Ltd., 185 Bartley Dr., Toronto 16, Ont.

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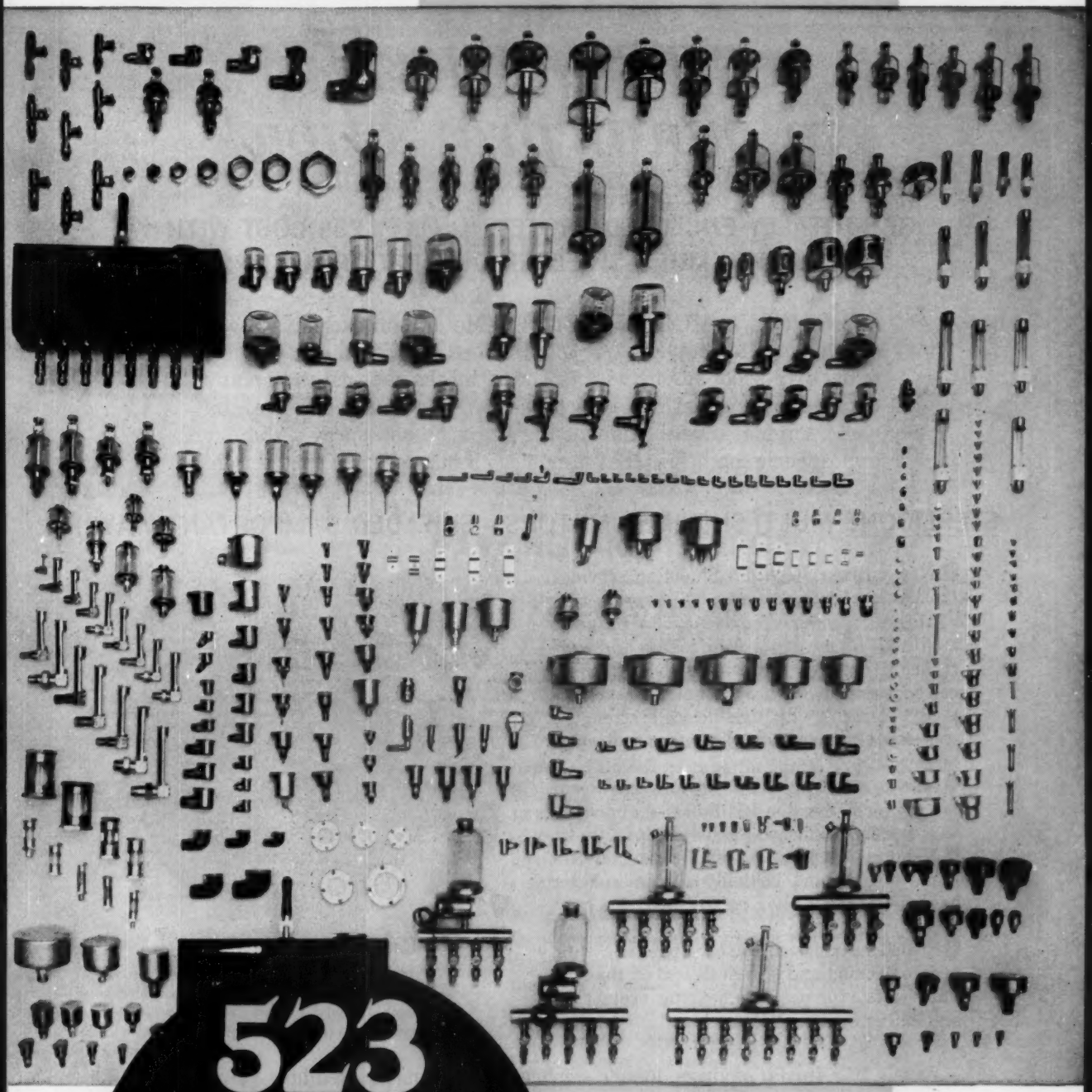

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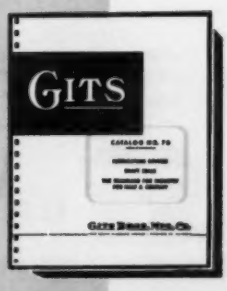

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Circle 479 on Page 19

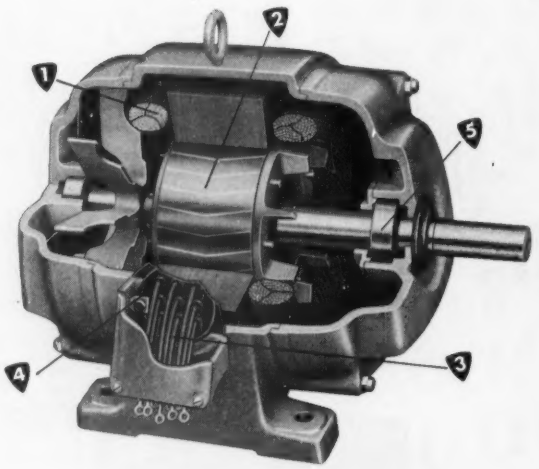
a new concept in motor protection!

GET TOTALLY ENCLOSED PROTECTION AT LESS COST WITH STERLICONE MULTI-SHIELDED DRIP-PROOF MOTORS!

STERLICONE M[illegible]TI-SHIELDED Motors, an exclusive development of Sterli[illegible]lectric Motors, Inc., now make it possible to use drip-proof [illegible]s with full overload characteristics on many demanding applications... such as food processing, chemical, oil well pumping, and others involving corrosion, salt spray or similar atmospheric conditions that previously required TEFC protection.

STERLICONE MULTI-SHIELDED MOTORS – SHIELDED 5 IMPORTANT WAYS!

1. New, proven *Sterlicone* Shielding provides flexible insulation for outstanding protection against most common environmental hazards. Achieved by multiple application and controlled processing to form a smooth, flexible coil encasement, *Sterlicone* Shielding is permanently resilient, with high dielectric strength; it does not become brittle like other protective materials.
2. Anti-corrosion coating provides extra protection for both rotor and fan.
3. Neoprene insulation shields all motor leads.
4. Neoprene gaskets and diaphragm seal terminal box against virtually all atmospheric hazards. Terminal box rotates 360° for easy access.
5. Sealed bearings are used... together with grease packing and labyrinth seal on the output shaft... for positive bearing protection and longer bearing life.



For initial savings, longer service life, lower required horsepower ratings and minimum maintenance, *STERLICONE* MULTI-SHIELDED Motors are your best buy. Get the facts about *STERLICONE* MULTI-SHIELDED Motors. Write for Bulletin 196.

STERLICONE MULTI-SHIELDED

STERLING ELECTRIC MOTORS, INC.

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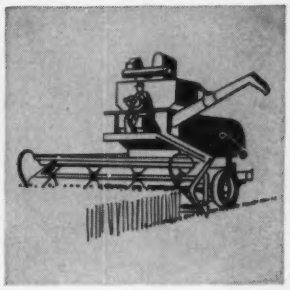
Graders



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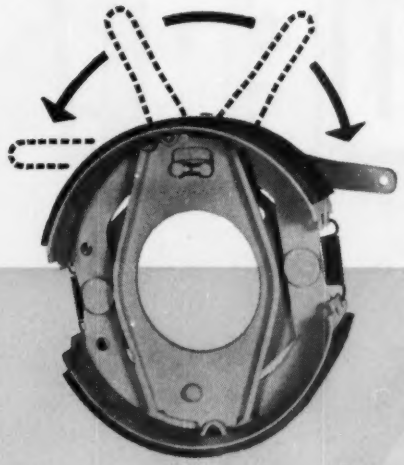


Check These Holdmaster Advantages:

Designed for versatility. 360° lever positioning makes brake standardization now possible for various installations. Cam and lever construction minimizes input force losses. Unique cam design applies brake with either direction of lever movement.

Simplicity of parts. The Holdmaster has only eight different parts! Inventory requirements are reduced . . . simple external linkage adjustment means easier, faster maintenance.

Rugged, lightweight construction. More braking capacity per pound is achieved through new design advances.

Improved high-capacity performance! With Rockwell-Standard's new balanced design, both shoes of the new heavy-duty Holdmaster Brake do an equal amount of work. This assures greatly improved mechanical efficiency . . . extends lining life and reduces transmission rear bearing stress.

As a parking brake, the Holdmaster provides sufficient torque capacity to prevent wheels from rolling on any grade. Equal torque output is exerted in either direction of rotation with minimum input force and stroke.

For emergency stops, the Holdmaster divides the input force equally between both shoes. Stops are safe and controlled for maximum protection. Heavy-duty design provides braking power even after several "panic" stops.

For full details, write for Holdmaster brochure. Every Rockwell-Standard Brake is backed by nearly a half century of engineering and manufacturing experience.

Another Product of...

ROCKWELL-STANDARD CORPORATION

'Brake Division, Ashtabula, Ohio

Circle 481 on Page 19

TALL ORDER!

ACIPCO 50-FT. MANDREL GIVES LONGER LIFE IN EXACTING APPLICATION

Completely fabricated and machined by ACIPCO, this 50-foot mandrel is giving longer, more durable service to an outstanding producer of power transmission poles, light standards, and other similar equipment. These products are produced by hydraulically forming steel plate around the mandrel.

Type 4330 alloy steel, heat treated to 300 minimum Brinell hardness for wear resistance and strength, was selected for this application. The mandrel—consisting of four ACIPCO centrifugally spun tubes threaded and screwed together—is 24″ in diameter with a 3″ wall and is provided with a 0°20′20″ taper from end to end. The O. D. is finish machined and belt polished to a 125 micro-inch finish to facilitate stripping the poles from the mandrel.

This is another example of ACIPCO versatility in action . . . of how ACIPCO'S wide range of sizes and analyses, and "one source—from start to finish" facilities can solve a complicated steel tubing problem, including YOURS!

ACIPCO
SPECIAL PRODUCTS
DIVISION OF AMERICAN CAST IRON PIPE CO.
BIRMINGHAM • ALABAMA

Circle 482 on Page 19

Circle 483 on Page 19→

flowability

MAKES THE DIFFERENCE

The specially shaped Nibs under the head of this Shakeproof® Thread-Cutting Screw are designed to act as torque brakes. As the screw is driven, the Nibs make contact with the work surface and "eat up" excessive driving torques. This prevents stripping the threads from over-tightening and also permits a broader range of driver settings.

For effective braking action, each Nib must be sharp and precisely formed. So, material must flow deep into the die cavities to fill out each Nib. Keystone XL Wire does the job—uniformly, consistently and precisely.

There are many other examples of how Shakeproof puts the *flowability* qualities of Keystone XL Wire to good use, increasing production and quality. If you'd like to learn more about these qualities, call your Keystone representative. Our metallurgists are at your service.

Keystone Steel & Wire Company, Peoria 7, Illinois

Sems-by-Shakeproof—5/16 diameter head plus shoulder makes this a good example of the *flowability* of Keystone XL Wire.

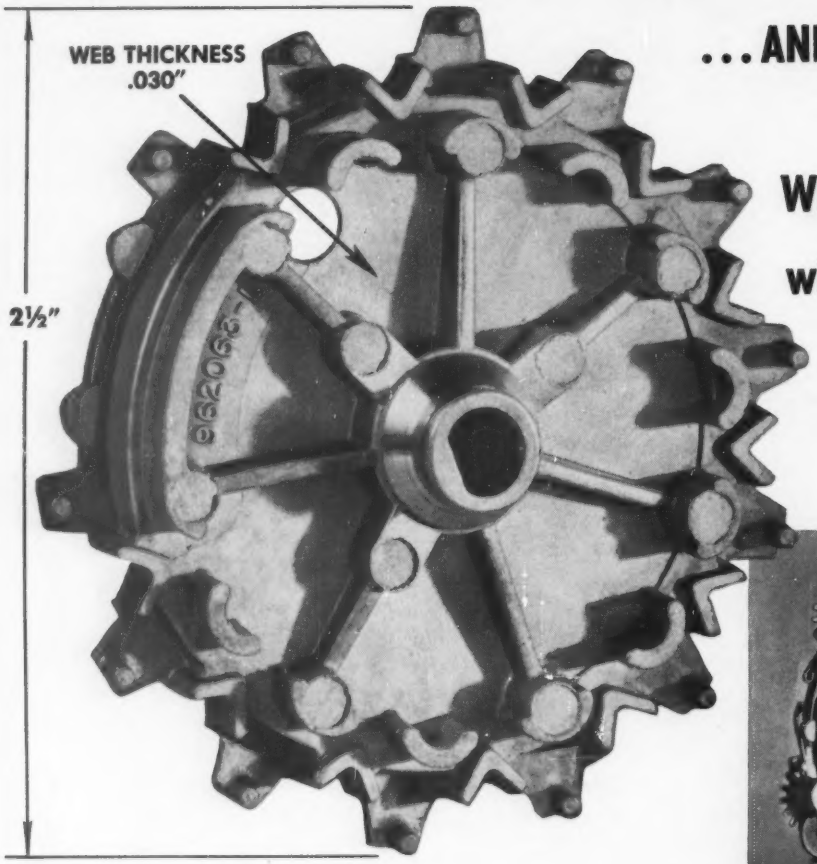
Mounting Screw combines left- and right-hand threads on the same shank as well as Nibs under the head. Left-hand thread and extruded lower thread section make this an exacting job.

KEYSTONE XL WIRE STUDY

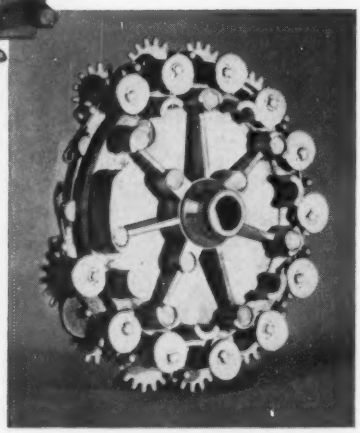
KEYSTONE

WIRE FOR INDUSTRY

IT'S LIGHTER THAN YOU THINK!



...AND UNBELIEVABLY PRECISE WHEN DIE CAST with ZAMAK



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- ELIMINATES COST OF SUB-ASSEMBLIES
- NOTHING TO WORK LOOSE — TROUBLE-FREE OPERATION
- RUGGED, EXTREMELY THIN WALL SECTIONS — *POSSIBLE ONLY WITH ZINC*

Precision engineered for RCA Victor television receivers, this complex, one-piece ZINC die casting is quickly assembled with gears and cams for locking each channel in fine-tuned position.

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THE NEW JERSEY ZINC COMPANY

DEVELOPERS OF THE ONLY STANDARD ZINC DIE CASTING ALLOYS IN USE TODAY

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HORSE HEAD PRODUCTS ®

MACHINE DESIGN
January 21, 1960

Who Wants To Be Boss?

IT IS part of the American dream to want to be the boss. Apart from the status attached to management and supervisory titles, our topsy-turvy system generally rewards managerial activity with higher salaries than the more creative engineering jobs.

How big is this extra reward for bossing other engineers? According to NSPE findings, the median salary for executive-administrative work is $12,480. This is 26 per cent higher than for R & D, and 38 per cent higher than for design.

In the upper brackets the differentials are greater. At the upper quartile the dollar figure is $17,750 —respectively 48 and 64 per cent higher than for R & D, and for design. At the upper decile the corresponding figures are $27,510, 85 per cent, and 100 per cent.

Is it surprising that, in a society where professional progress is measured by income, half of the engineers who graduated 25 years ago or more are now in executive-administrative work? Only one-quarter of the engineers in this age bracket are still devoting their mature talents to research, development, and design. Half of the engineers doing this type of work have been out of college 10 years or less.

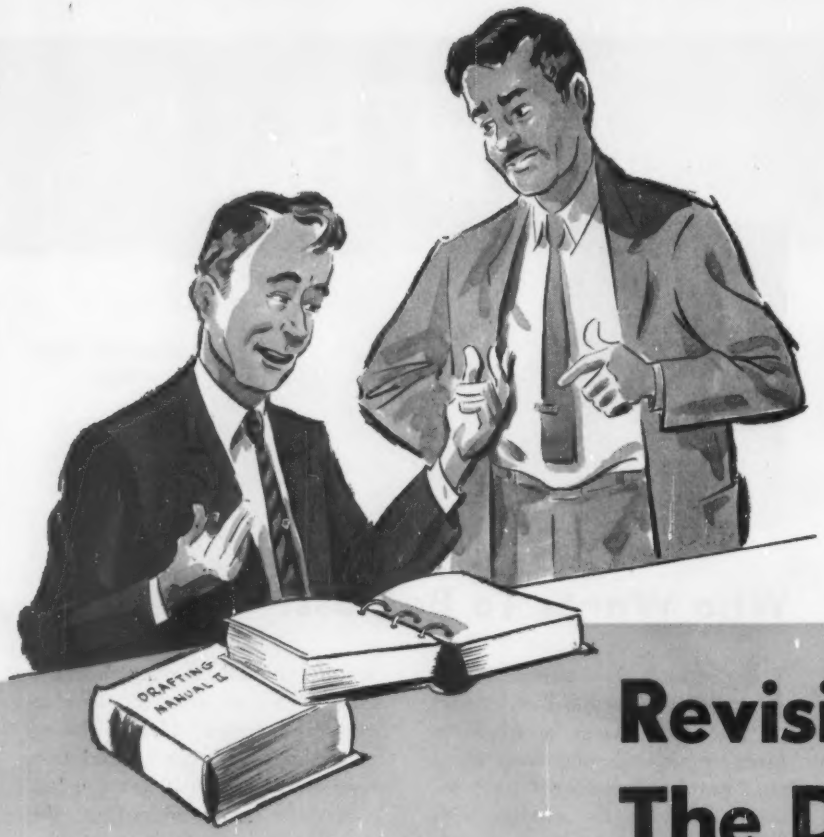
Statistics can be misleading. But the figures strongly suggest that competent c r e a t i v e engineering manpower, so badly needed in today's highly competitive world, is being lured by the income differential.

The remedy, which forward-looking companies have learned, is to create technical staff jobs, with such titles as advisory engineer and consulting engineer, which carry income and status comparable to the line supervisory and management jobs in the same organization.

If engineers could look forward to the prestige and income which a manager enjoys, while still doing engineering work, they might work harder at being good engineers and dream less about being boss.

Colin Carmichael

EDITOR



Revising The Drafting

. . . techniques for improving and updating the

S. W. BROSSMAN
Chairman, Language Arts Div.
Chaffey College
Ontario, Calif.

BASICALLY, drafting manuals are reference manuals. Like all good references, their primary requisite is ease of use, Fig. 1.

Any dictionary or encyclopedia is a reference book whose very format is completely designed around the one purpose of making entries easy to find. It is not desirable to make a dictionary out of a drafting manual, but there is much to learn from formats of reference works that have withstood the tests of time.

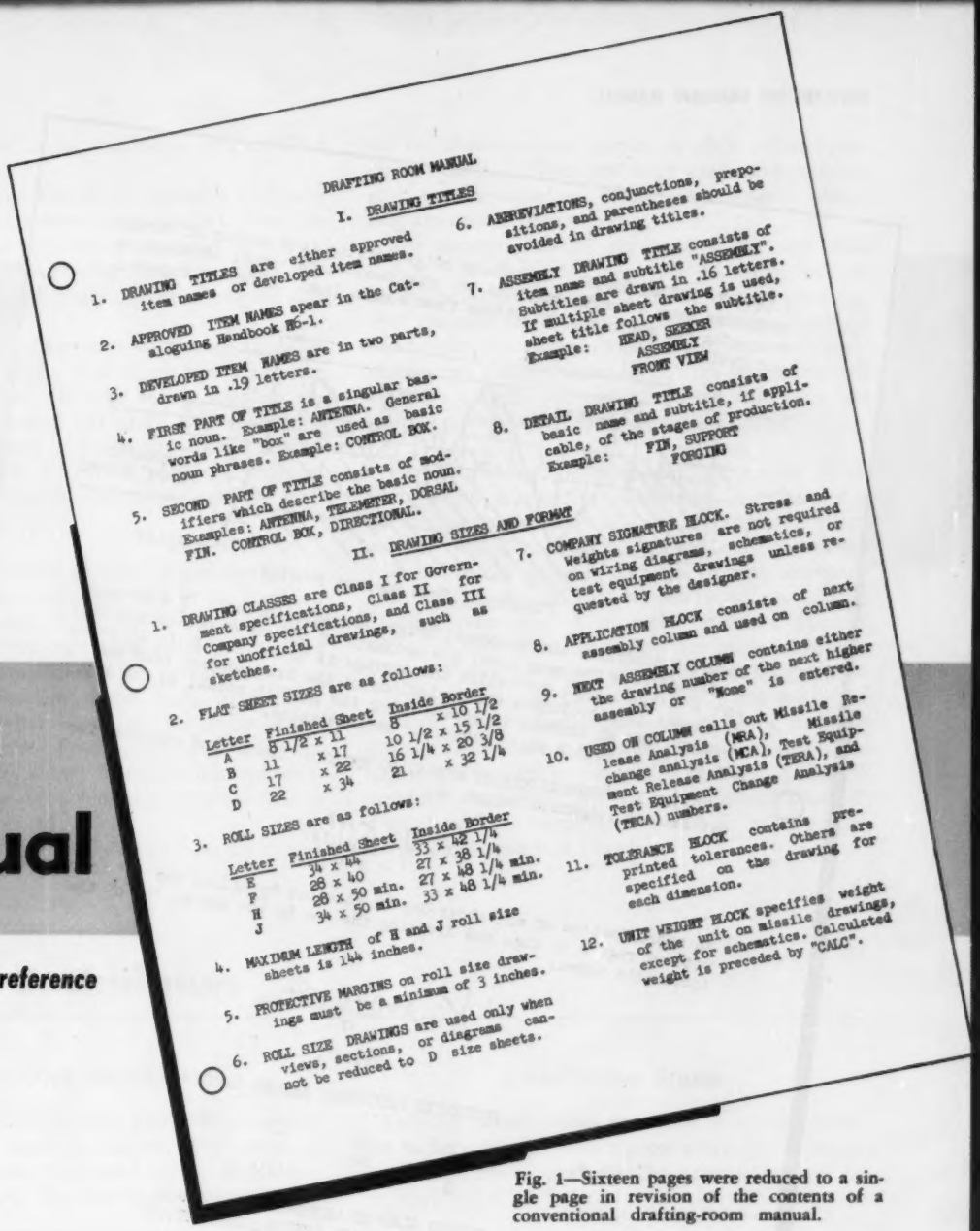
Of course, there's no argument that most drafting manuals need to be cleaned up periodically. But this has its limits, and after a while, it's better to rebuild completely.

Restriction of Content: First, the drafting-room manual should have some restrictions on what goes into it. In some, the fences are so far out that almost anything pertaining to drawings in the most remote way is dumped into their vast and lonely wastes. In course of time, shifting sands of drafting practices and drawing procedures, and desert dunes of release systems and design rules, all but camouflage the relatively few oases which are truly useful and necessary. Of course, some insist that even those cool spots are just mirages, but that's probably not fair criticism.

An excerpt from a typical manual is shown in Fig. 2. This material, while useful to a designer, merely clutters up the draftsman's Bible. Mathematical ratings of all kinds should be deleted or transferred to a design manual.

Manual

draftsman's basic reference



DRAFTING ROOM MANUAL

I. DRAWING TITLES

1. DRAWING TITLES are either approved item names or developed item names.
2. APPROVED ITEM NAMES apear in the Cataloguing Handbook H6-1.
3. DEVELOPED ITEM NAMES are in two parts, drawn in .19 letters.
4. FIRST PART OF TITLE is a singular basic noun. Example: ANTENNA. General words like "box" are used as basic noun phrases. Example: CONTROL BOX.
5. SECOND PART OF TITLE consists of modifiers which describe the basic noun. Examples: ANTENNA, TELEMETER, DORSAL FIN. CONTROL BOX, DIRECTIONAL.
6. ABBREVIATIONS, conjunctions, prepositions, and parentheses should be avoided in drawing titles.
7. ASSEMBLY DRAWING TITLE consists of item name and subtitle "ASSEMBLY". Subtitles are drawn in .16 letters. If multiple sheet drawing is used, sheet title follows the subtitle. Example: HEAD, SEEKER / ASSEMBLY / FRONT VIEW
8. DETAIL DRAWING TITLE consists of basic name and subtitle, if applicable, of the stages of production. Example: FIN, SUPPORT / FORGING

II. DRAWING SIZES AND FORMAT

1. DRAWING CLASSES are Class I for Government specifications, Class II for Company specifications, and Class III for unofficial drawings, such as sketches.
2. FLAT SHEET SIZES are as follows:

Letter	Finished Sheet	Inside Border
A	8 1/2 x 11	8 x 10 1/2
B	11 x 17	10 1/2 x 15 1/2
C	17 x 22	16 1/4 x 20 3/8
D	22 x 34	21 x 32 1/4

3. ROLL SIZES are as follows:

Letter	Finished Sheet	Inside Border
E	34 x 44	33 x 42 1/4
F	28 x 40	27 x 38 1/4
H	28 x 50 min.	27 x 48 1/4 min.
J	34 x 50 min.	33 x 48 1/4 min.

4. MAXIMUM LENGTH of H and J roll size sheets is 144 inches.
5. PROTECTIVE MARGINS on roll size drawings must be a minimum of 3 inches.
6. ROLL SIZE DRAWINGS are used only when views, sections, or diagrams cannot be reduced to D size sheets.
7. COMPANY SIGNATURE BLOCK. Stress and Weights signatures are not required on wiring diagrams, schematics, or test equipment drawings unless requested by the designer.
8. APPLICATION BLOCK consists of next assembly column and used on column.
9. NEXT ASSEMBLY COLUMN contains either the drawing number of the next higher assembly or "None" is entered.
10. USED ON COLUMN calls out Missile Release Analysis (MRA), Missile change analysis (MCA), Test Equipment Release Analysis (TERA), and Test Equipment Change Analysis (TECA) numbers.
11. TOLERANCE BLOCK contains preprinted tolerances. Others are specified on the drawing for each dimension.
12. UNIT WEIGHT BLOCK specifies weight of the unit on missile drawings, except for schematics. Calculated weight is preceded by "CALC".

Fig. 1—Sixteen pages were reduced to a single page in revision of the contents of a conventional drafting-room manual.

Sections of drafting-room manuals that deal with on-the-board drafting practices are more than useful; they're vital to the very operation of Engineering Department itself. Chief product of engineering, of course, is the drawing, and if standard and uniform practices are not observed in making drawings, foundation of the entire operation may become insecure.

Two Volumes Suffice: Drafting-room manuals, if possible, should be limited to two volumes, one volume for drafting practices and one volume for administrative drawing procedures. That these two sections should be separated is almost beyond argument. Some believe that drafting practices and drawing procedures are so unrelated that they shouldn't even share the same DRM family name. That may be going too far. Something has to be done with drawing procedures, and there's no harm in merely locking the door between them in separate volumes. If drawing procedures are mixed in, it is more difficult to find essential drafting practices such as line conventions, letter sizes, scales, notes, etc. Draftsmen will appreciate having irrelevant stuff (from their point of view) in a separate volume.

With a sensible organization split into two volumes, distribution will also be simpler. Draftsmen and engineers on the drawing board have no earthly use for administrative drawing procedures, so there's no reason to duplicate and distribute them needlessly and expensively to everyone. One copy of the

3.15.3.7 HEIGHT RATING. Roughness height rating is a rating of surface roughness over a length equal to the roughness-width cutoff obtained by averaging the microinch deviations from a mean line. Refer to Figure 3 and Table 1.

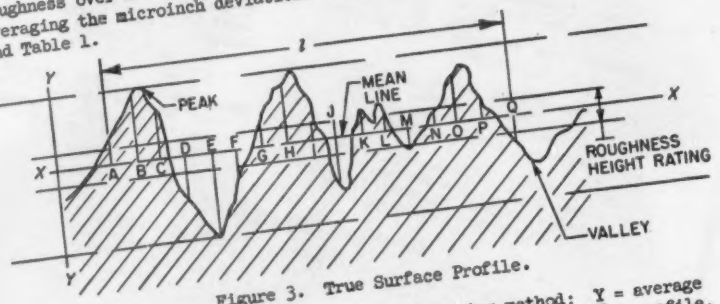


Figure 3. True Surface Profile.

Figure 3 describes the roughness height averaging method: Y = average deviation from the mean line, Y = ordinate of the curve of the profile, and l = the length over which the average is taken. A, B, C, D, etc., represent in microinches the deviations of the true surface from the mean surface at uniform intervals along the profile normal to the lay, or in the direction which gives the maximum value.

3.15.3.7.1 ROUGHNESS HEIGHT AVERAGING METHOD. The method required for determining roughness height is:

$$Y = \frac{1}{l}\int_{x=\sigma}^{x=l} |y|\,dx$$

An approximation of the above may be obtained by adding the 'y' increments without regard to sign and dividing the sum by the number 'n' of the increments taken:

$$Y = \frac{A+B+C+D+\ldots}{n}$$

Table I

PREFERRED ROUGHNESS HEIGHT RATINGS*

	16	125	1000
2	32	250	....
4	63	500	....
8			

*KNOWN ALSO AS ARITHMETICAL AVERAGE (AA) RATINGS AND CENTRE LINE AVERAGE (CLA) INDEX NUMBERS."

Fig. 2 — This excerpt from typical drafting-room manual may confuse draftsman.

volume containing drawing procedures could easily be accessible in central files. In this way, administrative information would be available without cluttering up the volume used by on-the-board personnel.

Importance of Page Layout: In addition to a logical organization of drafting-room manuals, redesign of page format may also be necessary. Text print should be no larger than 8-point to permit two columns on each page. A line 7 in. across a page not only prevents proper scansion, but also wastes space and time. Wide-page print also prevents efficient grouping of material, for items often take up only one line in many manuals. This doesn't mean that all material printed on 8½ by 11-in. paper should be in two columns. But it does mean that reference material is easier to find and read in two columns.

Often, headings are not distinguished sufficiently from text material. Headings should lap over into

the left margin and be big and bold—at least 12 or 14-point.

It's hard to believe, but Fig. 1 represents a revision of 16 pages from a conventional manual. Nor does this squeeze play in any way detract from usefulness of the manual. Only reason to reduce its size in first place is to make it more useful to on-the-board personnel.

There is no virtue *per se* in shrinking 16 pages down to one. The object isn't to see how much can be dried up, but to see how much needless explanation can be wrung out of it. And there's no doubt that excesses can be boiled out without cramping its style one bit. If positive parts are accented and negative parts are eliminated, style will be vastly improved.

Periodic Simplification: Finally, a periodic rewriting may also be necessary, especially in the direction of economy of words, simplicity of sentences, and elimination of irrelevancies. Occasional overhauling results in a more useful reference manual.

Writing for reference works isn't particularly tricky. It requires that words get the same thrifty respect given money. Prodigal phrases and uneconomical sentences merely lead to overdrawn paragraphs. Result may be a bankrupt manual that is either ignored or misread.

The most useful function that can be performed on the drafting-room manual is plain old red-penciling—cutting. There are large areas of repetitions and over-explanations whose very absence would help the reader immeasurably.

For example, there's no sense illustrating each vellum size. Personnel can just as easily look at actual vellums. Anyway, vellums change so often that manuals are hard put to keep up. Knocking out repetitions like explanations of first part of titles, eliminating a dozen examples of titles where one will do, and cutting out padded sheets will turn the manual into a much more useful document.

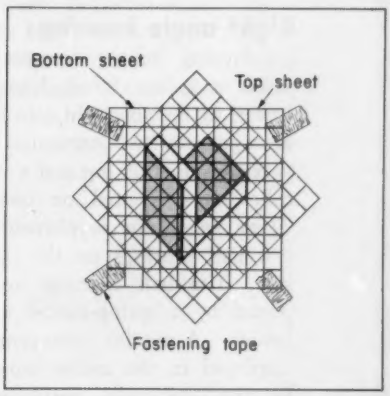
Revised Manual Saves Money: Of course, it all comes down to reduction of expenses. A revision will either save money or it will not. A properly written manual will save time of on-the-board personnel who are forced to wade through riptides of repetitions and backwashes of verbosity before finding drawing references. A properly organized manual will save time of redoing drawings made according to wrong interpretations of ambiguous instructions.

Value of revision speaks for itself. Time wasted in hunting down information or in misusing drafting practices may cost a great deal more money than expense of rewriting the entire manual. Although drafting errors never will be completely eliminated, a good drafting-room manual will go a long way toward achieving that Utopia.

Tips and Techniques

Perspective Sketches

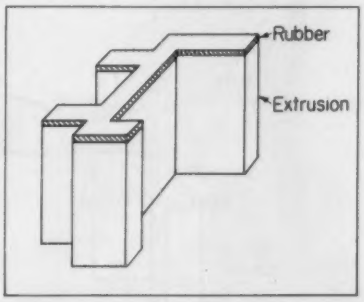
A quick background of guide lines for perspective sketching can be made as shown. One sheet of translucent grid paper is fastened on top of another at the desired angle. The top sheet forms a guide



for lines parallel to the picture plane. The lower sheet forms a guide for the vanishing point lines.—Paul N. Snyder, *GE Microwave Lab., Palo Alto, Calif.*

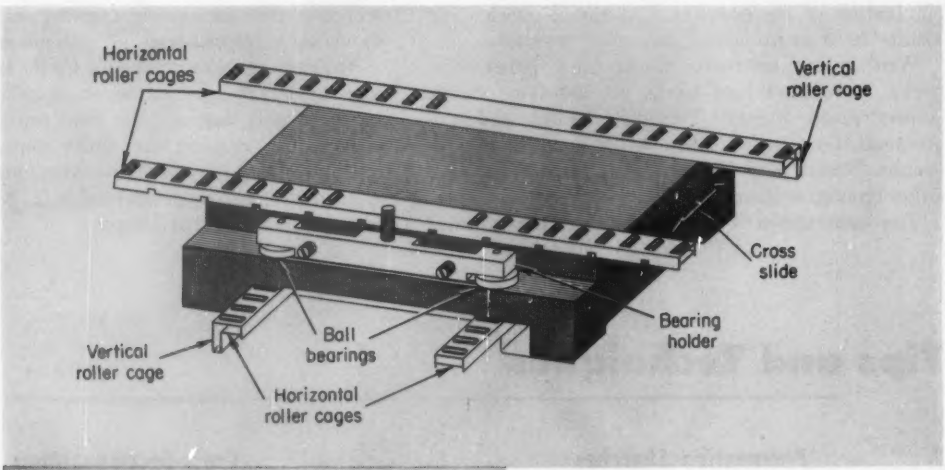
Cross-Section Stamp

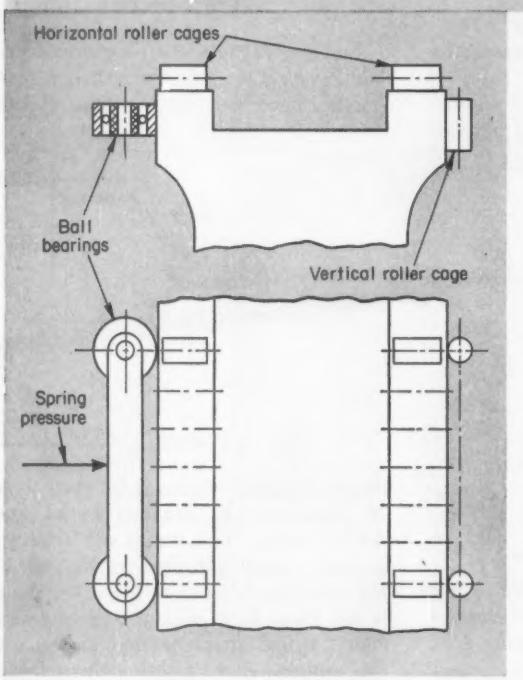
Full-size layouts often require a structural member to be shown in cross-section a number of times. Smaller members such as the extrusions used in



designing metal windows, for example, can be rapidly placed on the drawing as an imprint from a rubber stamp. The stamp can readily be made by gluing a sheet of rubber to the end of a sample of the member. After the glue dries, the excess rubber is cut away flush with the sample sides, forming a stamp whose shape is that of the cross-section of the sample.—J. Classens, *Maastricht, Holland.*

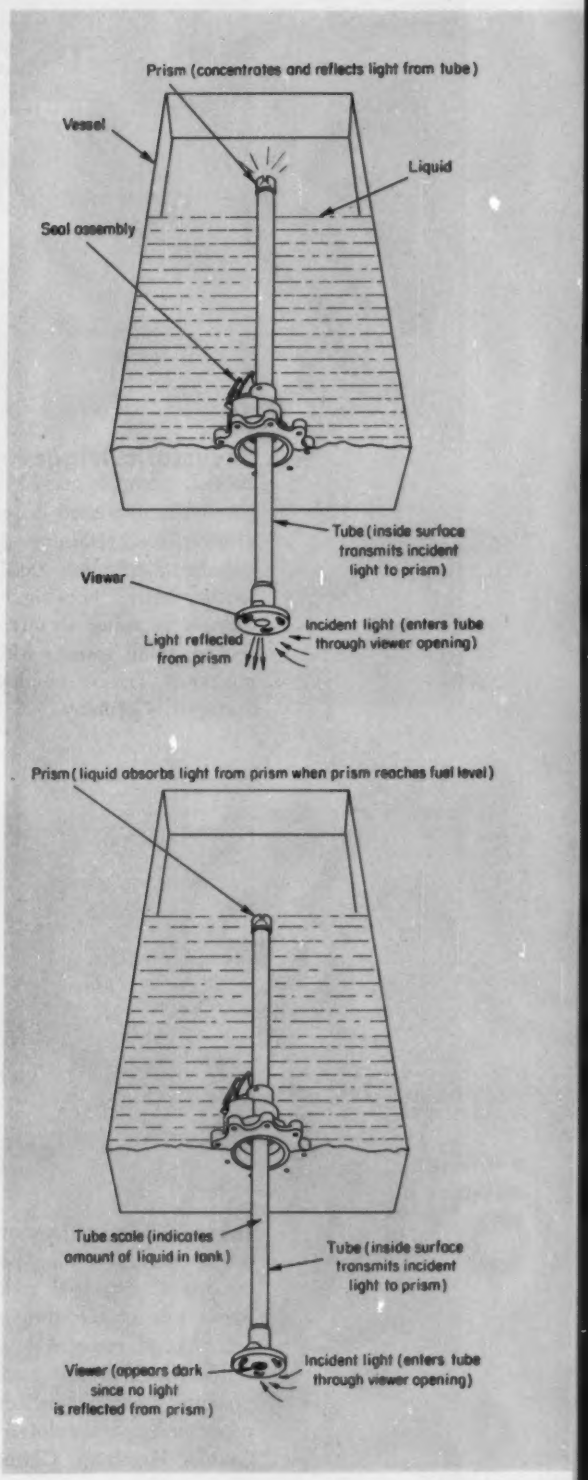
scanning the field for *ideas*

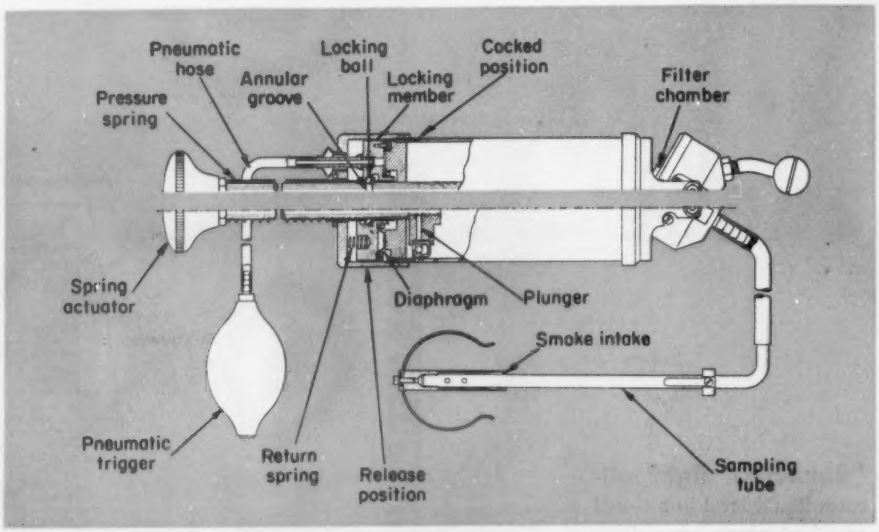




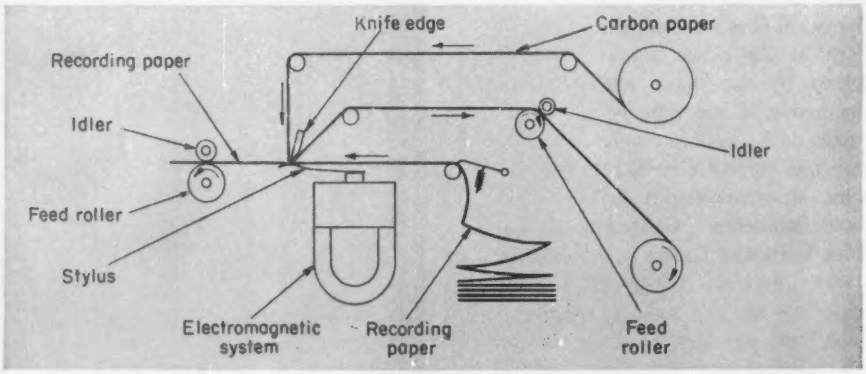
Right angle bearings provide low-friction rolling contact and serve as guides for high-precision traversing members. In a cross slide arrangement, two horizontal roller cages are used on top and a vertical roller cage is used on one side. These cages are supplemented by two ball bearings on the opposite side. The ball bearings are supported by a spring-loaded bearing holder. A similar arrangement is employed in the saddle mounting. Bearing principle employed in microscope developed by Ernst Leitz, GmbH, Wetzlar, Germany.

"Bouncing" light indicates liquid level in a closed vessel. A plastic slip-tube is mounted in the bottom of the vessel. Incident light, passing through a viewer window in the base of the slip tube, is transmitted through an inner plastic tube to a prism at the opposite end. If the prism is out of the liquid, the prism concentrates and reflects the light, illuminating the inside of the tube. When the top of the tube is moved down into the liquid and the prism is submerged, the light in the prism is absorbed by the liquid and the inside of the tube becomes dark. Reflected-light principle employed in BLIP sight gage developed by Sierra-Schroeder Controls Div., Glendale, Calif.

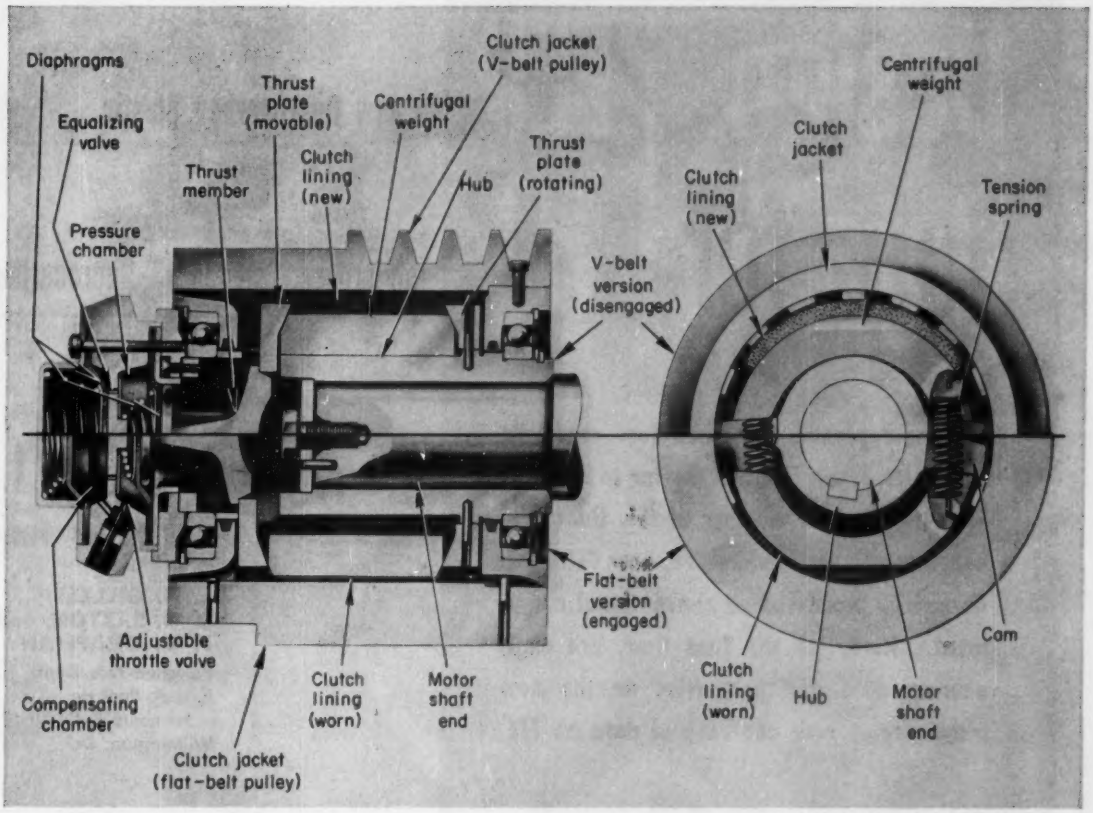

Prism (concentrates and reflects light from tube)
Vessel
Liquid
Seal assembly
Tube (inside surface transmits incident light to prism)
Viewer
Incident light (enters tube through viewer opening)
Light reflected from prism
Prism (liquid absorbs light from prism when prism reaches fuel level)
Tube scale (indicates amount of liquid in tank)
Tube (inside surface transmits incident light to prism)
Viewer (appears dark since no light is reflected from prism)
Incident light (enters tube through viewer opening)



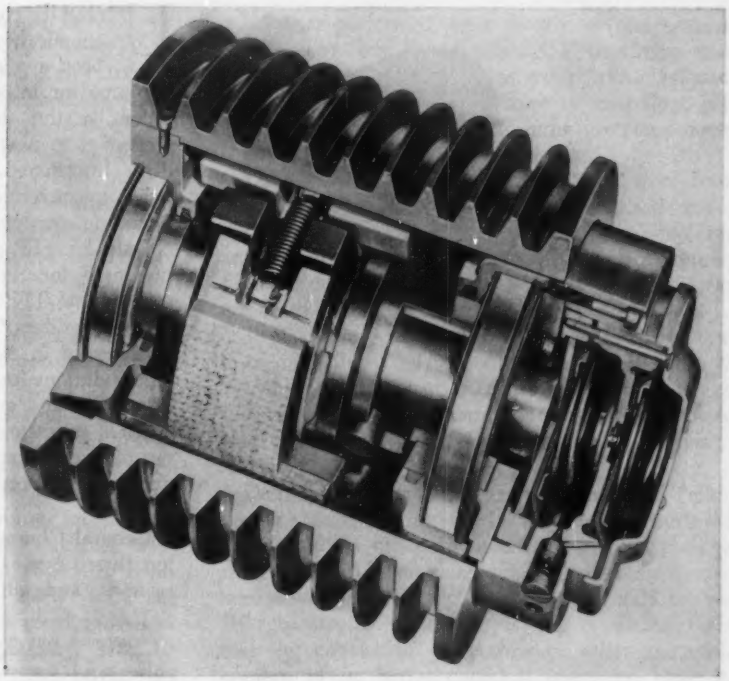
Pneumatic trigger remotely controls operation of detent mechanism. A cushion pump is cocked manually by depressing a spring actuator. As the plunger rod is depressed, a set of locking balls engage with an annular groove in the plunger rod, retaining the plunger in a cocked position. Air pressure on an annular diaphragm axially displaces an annular locking member holding the locking balls. Locking balls are released from the plunger-rod groove, and the plunger is pulled through its stroke by spring pressure. As the plunger is again cocked, small springs within the pump return the locking member to its original position. Trigger employed in Smokmeter developed by Robert Bosch, GmbH, Stuttgart, Germany.



Inkless recording with conventional carbon paper produces continuous curve on standard recording paper. The recording paper is pulled across a knife edge by one of two feed rollers. Carbon paper is also pulled across knife edge on upper side of recording paper, but in opposite direction at speed approximately 1/6 that of recording paper. Electromagnetic system below the rollers controls stylus which presses recording paper against carbon paper at a constant contact pressure. Angular deflection of stylus produces curve on moving paper. Carbon-paper principle employed in continuous-line recorder developed by Elektro Spezial GmbH, Hamburg, Germany.



Hydraulic cushions counteract radial motion of centrifugal weights to smooth engaging action in centrifugal clutch. Keyed to motor shaft end, a hub with cams rotates flyweights which move outward as motor gains speed. Flyweights exert pressure on axially movable thrust plate, limiting radial motion. Thrust member causes pressure-chamber diaphragm to force hydraulic fluid into compensating chamber through adjustable throttle valve. As thrust plate gradually releases centrifugal weights, clutch lining starts to engage with clutch jacket interior. Engagement is completed after adequate fluid volume has passed from pressure chamber to compensating chamber. Hydraulic-cushion principle employed in centrifugal clutch designed by Flender GmbH, Bocholt, Germany.



NEW Design Data for FEP — a new fluorocarbon plastic | TFE — the proved "standard" fluorocarbon

A new plastic—FEP—has just made its bow. Its properties are similar to those of TFE—the original member of this fluorocarbon family. But, unlike TFE, new FEP plastic can be processed on conventional equipment. Here, for the first time, are engineering data and properties on the new plastic—plus new and revised data on TFE.

Part 1—

L. H. GILLESPIE, D. O. SAXTON, and F. M. CHAPMAN
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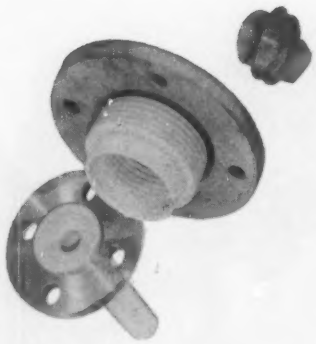


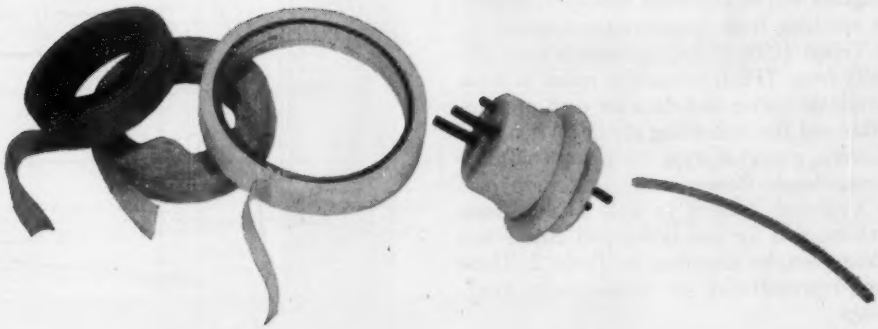
UNIQUE combinations of electrical, thermal, chemical, and frictional characteristics have been available in TFE plastic (an abbreviated name for tetrafluoroethylene). Now, a new addition to the fluorocarbon family extends these properties to new shapes. Unlike TFE, new Teflon FEP (fluorinated ethylene-propylene) can be processed in conventional plastic injection-molding and extruding equipment.

Data for FEP are completely new and are being presented for the first time. The greatest portion of data for TFE is also new or has been revised from earlier data.*

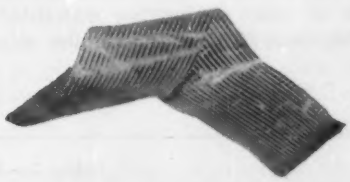
Presented in two parts, engineering data and recommendations for TFE and FEP resins are arranged in tabular and graphical form for easy comparison. General characteristics, design considerations, properties of strength and stiffness, and the effects of time under load are covered in this first article.

General Characteristics: Fabricated shapes of Teflon fluorocarbon plastics are tough, flexible in thin sections, and fairly rigid in thick sections. Useful

*"Designing with Teflon"; MACHINE DESIGN; Part 1, September 5, 1957, p. 86; Part 2, September 19, p. 162; Part 3, October 3, p. 124; Part 4, October 17, p. 124.



—Strength and Deformation



mechanical properties are maintained from −450 F to 500 F for TFE and from −450 F to 400 F for FEP. Surfaces of fabricated parts have an extremely low coefficient of friction—almost nothing sticks to them. However, specially treated surfaces will accept conventional industrial adhesives. TFE and FEP plastics are almost completely inert to chemical attack but, under special conditions, are affected by such substances as alkali metals and halogens. Low-loss electrical characteristics remain essentially constant, regardless of frequency, over a wide temperature range.

TFE resins tend to be opaque, crystalline, and malleable. While Teflon FEP-fluorocarbon resins are also crystalline and malleable, they are translucent and actually transparent in thin sections.

Fabrication procedures for TFE and FEP resins are different. Teflon TFE-fluorocarbon resin can be aggregated into dense, coherent shapes at normal temperatures by various "preforming techniques" which apply uniform pressure to the unheated TFE plastic. Preformed products are strengthened by heating above 620 F, generally 700 to 720 F, until the resin particles coalesce, and then cooling below 620 F. Products sintered in this manner may be further shaped by various postforming techniques which are performed most readily at temperatures approaching but below the 620 F transition temperature. Because TFE resins enter into a gel state at 621 F which is not conducive to melt flow, preforming, sintering, and postforming are the processing techniques most commonly used.

FEP resins, however, exhibit a melt flow comparable to most commonly used thermoplastic resins and can be processed in conventional plastic molding and extruding equipment. Shapes that are extremely difficult or impossible to mold with TFE plastics are often obtained easily with FEP resin.

Typical compositions for TFE and FEP are outlined in Table 1. The manner in which many of the characteristics can be controlled or varied, and the results of these manipulations, are discussed separately in *Effects of Processing on Properties.*

Design Considerations: Parts to be made of Teflon may be designed in exactly the same manner as parts made of other engineering materials such as steel, brass, lead, concrete, etc. Even the same formulas may be used if careful attention is paid to special characteristics of the plastics. A Teflon resin may be chosen in preference to other materials because of its better chemical inertness, heat re-

sistance, friction coefficient, dielectric strength, toughness, weather resistance, or combination of such properties. Most materials are affected to some extent by temperature, moisture, and environment. Since Teflon plastics exhibit zero moisture absorption and are unaffected by almost all environmental conditions, designers will be interested mainly in property changes resulting from temperature variation.

Because Teflon 100X FEP-fluorocarbon resin differs markedly from TFE-fluorocarbon resins in some respects, available curves and data for each are presented in this and the succeeding article. When load is applied over a period of time, creep and cold flow must be considered. Consequently, data are presented for long-term loading as well as short-term loading. Information for the tables and charts was obtained from samples described in Table 2. These samples are representative of commercially available moldings.

Strength, Stiffness, and Effects of Time: Teflon fluorocarbon resins are engineering materials whose performance in any particular application may be predicted by calculation in the same manner as for other engineering materials. However, just as properties of woods are different from those of metals, the properties of Teflon resins are different from those of other engineering materials. From the following data, strength and stiffness values can

1a

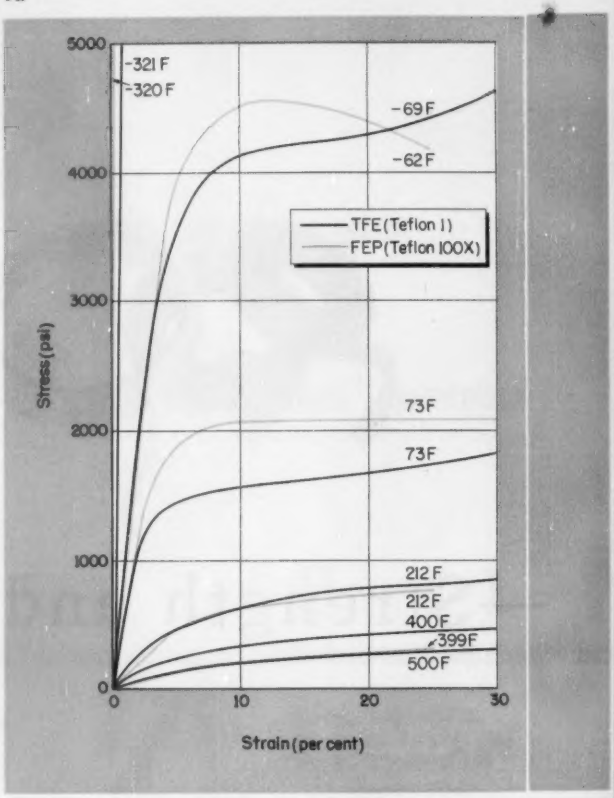


Table 1—Teflon Fluorocarbon Resins

Resin	Usual Method of Processing	Description	Major Uses
TFE			
Teflon 1	Molded by preforming-sintering technique. Ram extruded.	General-purpose powder for molding and extrusion.	Gaskets, packings, seals, electronic components, bearings, sheet, rod, heavy-wall tubing.
Teflon 5	Molded by preforming-sintering technique. Ram extruded.	Special molding powder—granulated for molding cylinders for skived tape.	Tape and molded shapes for chemical, electrical, mechanical, and nonadhesive applications.
Teflon 6	Lead-press type extrusion.	Special-purpose powder for compounding and for use in extrusion.	Thin-walled tubular goods, wire coatings, electrical tape.
Teflon 7	Molded by preforming-sintering technique. Ram extruded.	Special molding powder—granulated for use where highest quality, void-free moldings are required.	Molded sheets, tape, wire wrapping, tubing, gasketing.
Teflon 30	Dip coating.	Aqueous dispersion.	Impregnation of glass cloth and asbestos.
Teflon 41BX	Compounding.	Aqueous dispersion.	Electronic components, gasketing.
FEP			
Teflon 100X	Injection or compression molding. Melt extruded.	⅛-in. resin cubes for conventional molding or extrusion equipment.	Complex moldings, encapsulation, coating, wire jacketing, printed circuits.

Table 2—Description of Samples Used in Tests

Fabricated Form	Average Specific Gravity	Void Content	Crystallinity	Preform Pressure (psi)
TFE				
Rod, 6-in. long x 0.6-in. diam	2.17	<0.3%	60%±2%	2500
Sheet, 14 in. x 14 in., ⅛ and 1/16-in. thick	2.17	<0.3%	60%±2%	2500
FEP				**Molding Pressure**
Rod, 1-in. long x 1-in. diam	2.14	.....	.....	10,000 (est.)
Sheet, 14 in. x 14 in., ⅛ and 1/16-in. thick	2.15	.....	.....	10,000 (est.)

1b

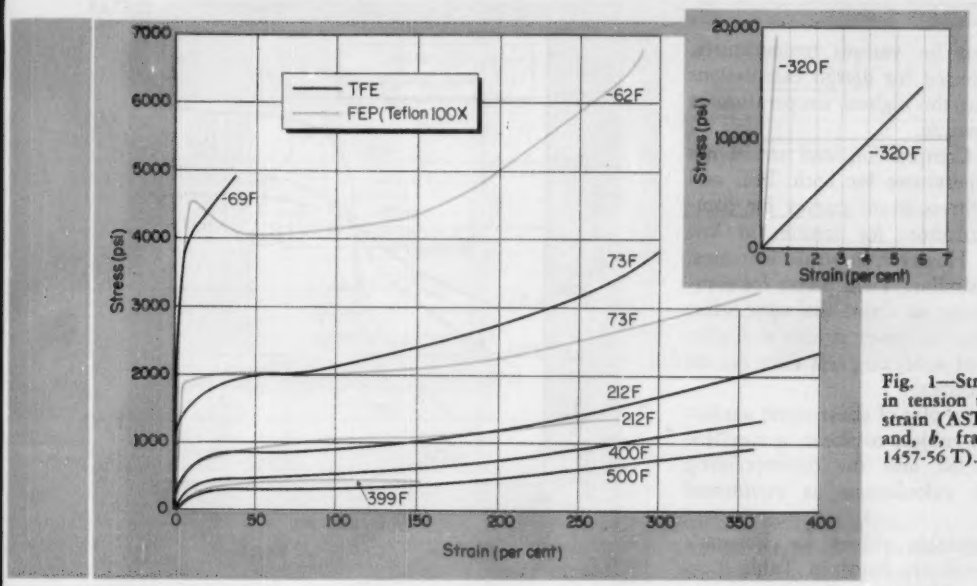


Fig. 1—Stress versus strain in tension to, *a*, 30 per cent strain (ASTM D 1427-56 T) and, *b*, fracture (ASTM D 1457-56 T).

be selected which, with appropriate safety factors, will allow standard engineering formulas to be used in designing parts.

Tensile Stress: Stress-strain curves for temperatures in the usual design range, Fig. 1*a*, show that yield occurs at high deformations. Elastic response begins to deviate from linearity at strains of only a few per cent as with most plastics. Therefore, in designing with Teflon, it is often best to work with acceptable strain and determine the corresponding stress. Curves which show ultimate tensile strength, the point at which fracture occurs, are given in Fig. 1*b*.

Because of the difficulty of establishing a yield point in plastics, good practice often dictates the use of stress at a specified strain. Fig. 2 shows strain

2

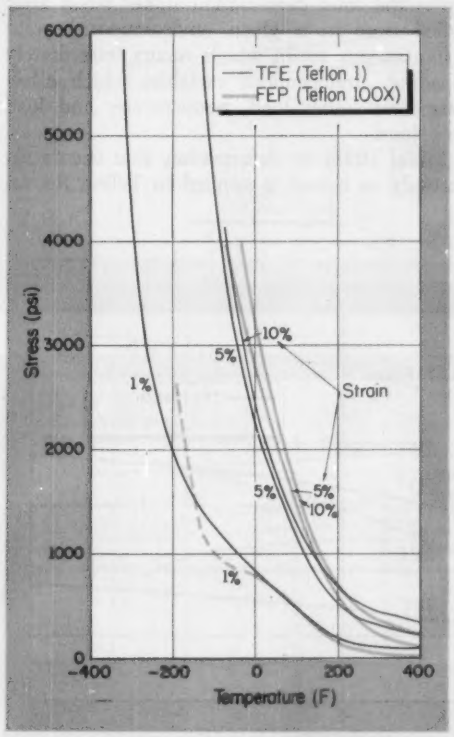


Fig. 2—Tensile stress versus temperature (ASTM D 1457-56 T).

3

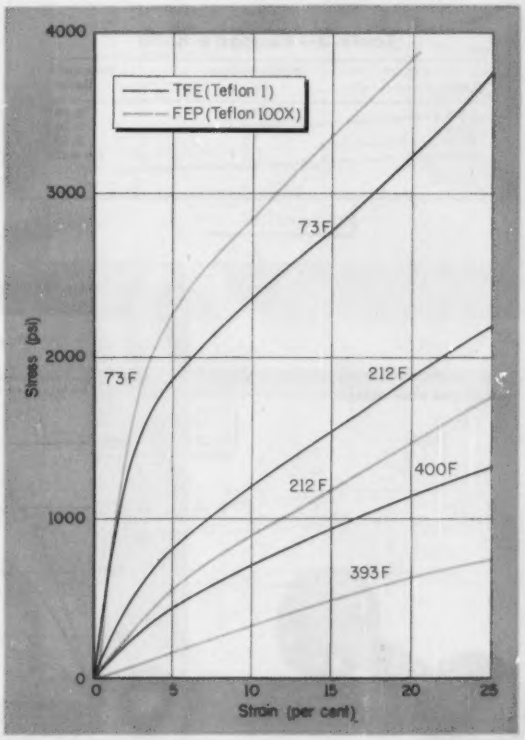


Fig. 3—Stress versus strain in compression (ASTM D 695-54).

at corresponding stresses for various temperatures. The per cent strain selected for design calculations should take into account the highest temperature at which the part will operate.

Compressive Stress: Compression and strain are indicated at three temperatures for both TFE and FEP plastics, Fig. 3. Stress-strain curves for compression are similar to those for tension at low values of strain, Fig. 4. However, as strain increases, the curves become less similar. Yield points for compression and tension occur at about the same stress values. For compression, the lower strains at higher stress may be a result of analyzing test data on the basis of original cross sections.

Shear Stress: Fig. 5 is a plot of shear stress against shear strain. In a part subject to shear, a specified strain should be selected and the corresponding stress used for design calculations as mentioned previously.

Poisson's Ratio: Available values for Poisson's ratio at two temperatures are listed in Table 3.

Modulus of Elasticity: No attempt has been made to include data on modulus of elasticity. Since modulus of elasticity E is

$$E = \frac{\text{Stress (psi)}}{\text{Strain (in./in.)}} \qquad (1)$$

the preceding stress-strain curves permit substitution, when working at a specified strain, of the corresponding stress so that modulus of elasticity can be determined.

Table 3—Poisson's Ratio

Resin	Temperature (F)	Poisson's Ratio
TFE	73	0.46
TFE	212	0.36
FEP	73	0.48
FEP	212	No data

4

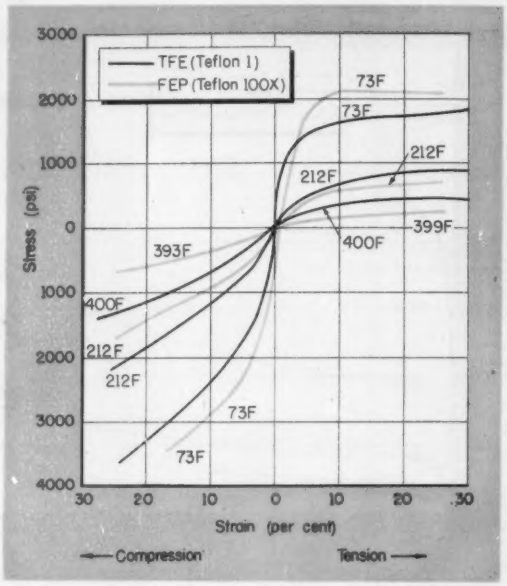


Fig. 4—Curves of stress versus strain in tension (ASTM D 1457-56 T) and compression (ASTM D 695-54).

Creep and Cold Flow: A plastic material subjected to continuous load experiences a continued deformation with time that is called creep or cold flow. A similar phenomenon occurs with metals at elevated temperatures. With most plastics, however, deformation can be significant even at room temperature or below; thus, the name "cold flow."

Creep is the total deformation under stress after a specified time in a given environment beyond that instantaneous strain which occurs immediately upon loading. Independent variables which affect creep are time under load, temperature, and load or stress level.

The initial strain or deformation that occurs instantaneously as a load is applied to Teflon fluoro-

5

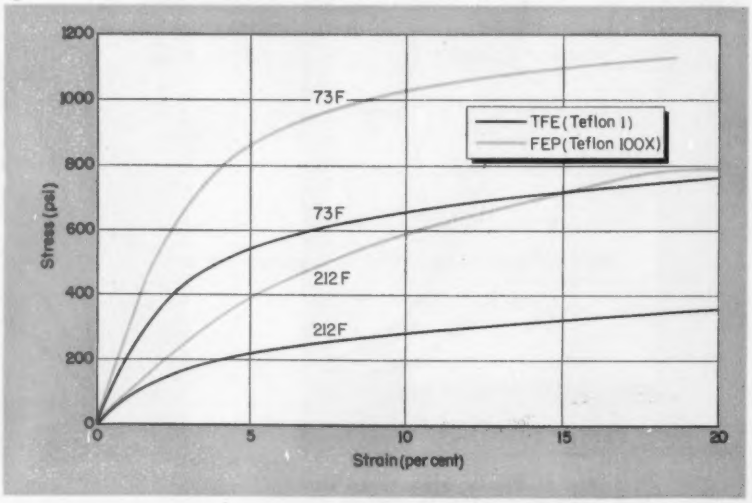


Fig. 5—Stress versus strain in shear to 20 per cent strain.

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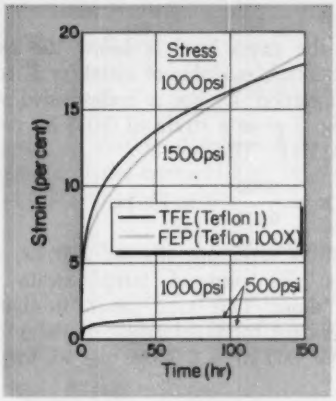

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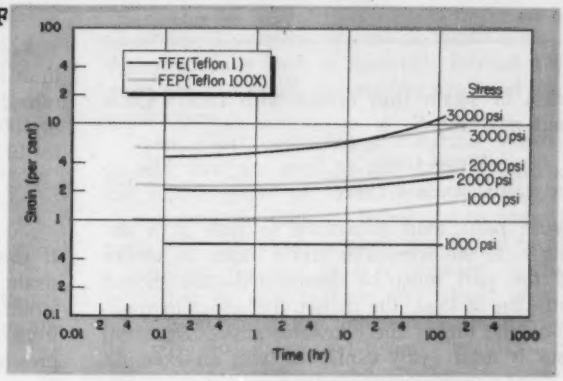

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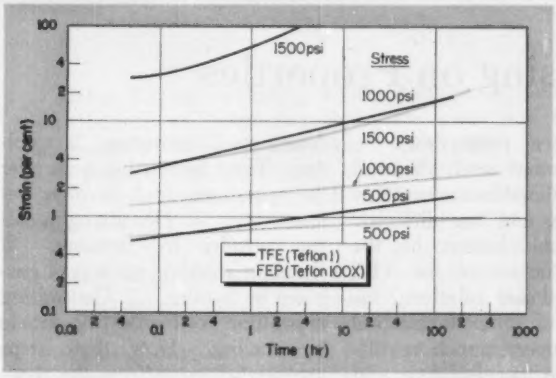
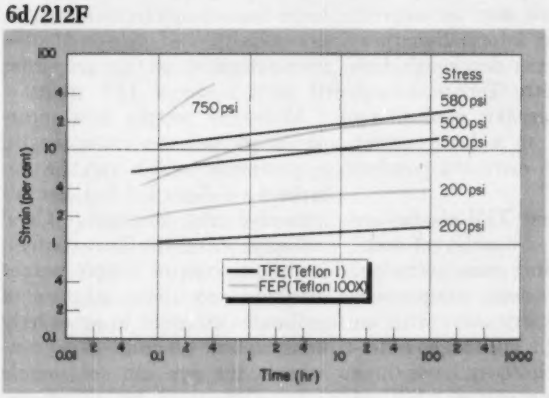


carbon resins is shown in Fig. 6*a*. Following this initial strain is a period during which the part continues to deform but at a decreasing rate. Creep data over a wide range of t mperatures are plotted for tensile loading in Fig. 6*b* through 6*e*, for compressive loading in Fig. 7, and for torsional loading in Fig. 8.

Apparent Modulus of Elasticity: The concept of "apparent modulus" is a convenient method for expressing creep because it takes into account initial strain for an applied stress plus the amount of de-

6d/212F



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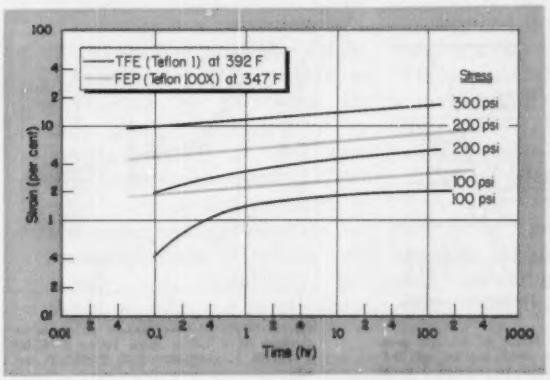
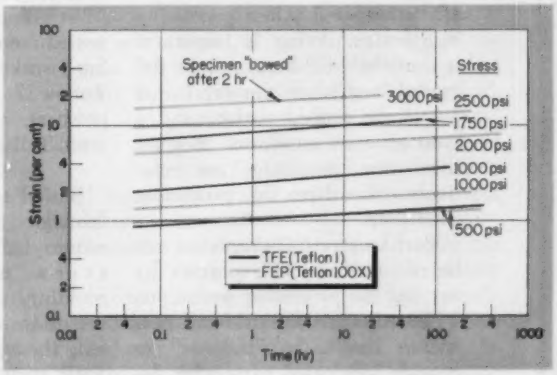


Fig. 6—Total deformation versus time under tensile load.

7a/73F



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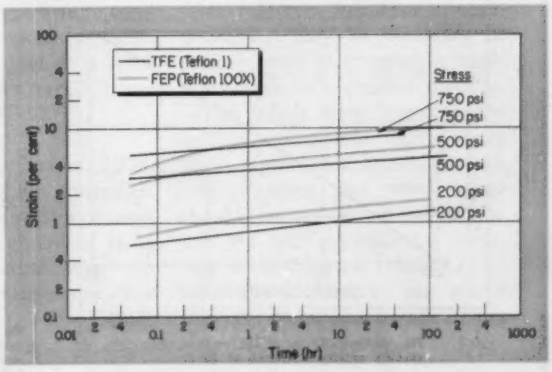

Fig. 7—Total deformation versus time under compressive load.

formation or strain that occurs with time. Thus, apparent modulus E_A is

$$E_A = \frac{\text{Stress (psi)}}{\text{Initial strain + Creep}} \qquad (2)$$

Because parts tend to deform in time at a decreasing rate, the acceptable strain based on service life of the part must be determined—the shorter the duration of load, the higher the apparent modulus, and the higher the allowable stress. Apparent modulus is most easily explained with an example.

As long as the stress level is below the elastic limit of the material, modulus of elasticity E is obtained from Equation 1. For a compressive stress of 1000 psi, Fig. 3 gives a strain of 0.015 in. per in. for FEP resin at 73 F. Then,

$$E = \frac{1000}{0.015} = 66{,}700 \text{ psi}$$

If the same stress level prevails for 200 hr, total strain will be the sum of initial strain plus strain due to time. This total strain is obtained from Fig. 7*a* where total deformation under compressive load for 200 hr is 0.02 in. per in. for FEP

Effects of Processing on Properties

Because FEP resin exhibits flow characteristics similar to those of the most commonly used thermoplastic resins, many processing limitations of TFE plastics do not apply. For example, preforming pressure, sintering time, cooling rate, void content, and crystallinity level—all of which are important in processing TFE resins—are not usually considered when processing FEP resins. What is important is that the FEP resin not be degraded and that the fabricated part have a good surface and a homogeneous structure. Beyond this, most properties are relatively insensitive to processing conditions.

Various physical properties can be obtained in TFE plastics by varying the processing technique. TFE resins are versatile and can, within limits, be "tailored" to provide fabricated parts with desirable physical properties.

Good thermal and chemical resistance, nonadhesiveness, low power factor, and low dielectric constant are inherent in the chemical structure of the TFE molecule and are relatively independent of the fabrication method. Properties such as stiffness, flex life, permeability, and tensile strength can be altered. Most of the information presented here was developed during work with Teflon 1 and Teflon 7 granular molding powders, and to a lesser extent with Teflon 6 extrusion powder.

Basic Factors: TFE plastics are fabricated by a number of techniques including ram extrusion, screw extrusion, compression molding, and extrusion with an extrusion aid. Although different, these techniques have three basic steps in common: 1. Cold forming. 2. Sintering. 3. Cooling. These fabricating steps refer to operations that involve, respectively: 1. Densifying molding powder by pressing. 2. Bonding adjacent surfaces of particles by heating. 3. Controlling crystalline content of the article by cooling. How these steps are carried out affects the three basic factors—molecular weight, crystallinity, and void content—that determine certain properties of parts made of TFE resins.

Molecular weight is a measure of the polymer chain length, a parameter which can be decreased or degraded but not increased during processing. Crystallinity, or crystalline content, is the per cent of sample weight attributed to those portions of molecules arranged in an orderly or crystalline manner. Void content is the per cent of sample volume occupied by air spaces.

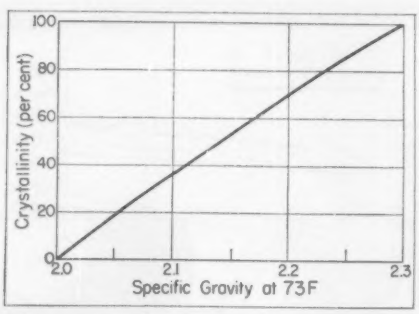

Fig. A—Crystallinity of TFE resin versus specific gravity measured at 23 C.

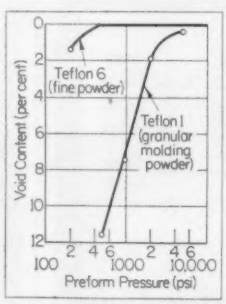

Fig. B—Effect of preform pressure on void content of TFE-resin moldings sintered 3 hr at 716 F.

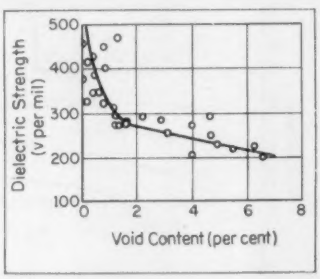

Fig. C—Effect of void content on dielectric strength of 0.060-in. thick Teflon 1 (ASTM D 149-49 T, short-time test, Primol D test oil).

resin. Therefore,

$$E_A = \frac{1000}{0.02} = 50{,}000 \text{ psi}$$

Similarly, E_A can be determined for one year. Extrapolation of the curve in Fig. 7*a* gives a deformation of 0.025 in. per in., and

$$E_A = \frac{1000}{0.025} = 40{,}000 \text{ psi}$$

When plotted against time, these calculated values for "apparent" modulus provide an excellent means for predicting creep at various stress levels. For all practical purposes, curves of deformation versus time eventually tend to level off. Beyond a certain point, creep is small and may be neglected for many applications.

Stress Relaxation: When materials which creep or cold flow are used as gaskets in flanged joints, the phenomenon of stress relaxation is generally encountered. In flanged, bolted connections, Teflon parts will cold flow between the flange faces with a resultant decrease in bolt pressure. Such stress relaxation in gasket stock may result in a leaky joint. Tightening the flange bolts during the first day after installation will usually maintain bolting

Other factors, including void distribution or void size, and orientation, which help determine the properties of parts made of TFE resin, cannot be readily measured.

Methods of Measurement: Before the importance of the three basic factors can be discussed, methods of measurement must be outlined. Specific gravity can be used to show relative molecular weight of different samples of resin. As Table A shows, at least two other factors affect specific gravity, but their influence is eliminated by preparing moldings under identical conditions. A standard set of molding conditions has been established in ASTM Specification D 1457-56 T, and specific gravity measured on a molding in accordance with this specification is known as the standard specific gravity. Because this value ranks the resins according to their molecular weight, standard specific gravity is a convenient relative measure of molecular weight.

Relative crystallinity may be determined by measuring the ratio of the absorbance of infrared radiation at two wave lengths in a thin section. Two other methods are provided by measuring torsional modulus and resiliency, both of which vary rapidly with crystallinity. Torsional modulus can be calculated for a torsion pendulum used to measure the rate of torsional oscillation of a molded rod or bar. Resiliency is determined with a scleroscope.

Void content of a molding is determined by its measured specific gravity and the specific gravity it would have if no voids were present. The latter value, known as inherent polymer specific gravity, is determined by measuring crystallinity and obtaining the corresponding specific gravity from Fig. A. Crystallinity may also be estimated, if cooling or annealing conditions are known, from data in Tables B and C. Then, void content is

$$V = \frac{S_i - S_m}{S_i} \times 100$$

where V = per cent void content; S_i = inherent polymer specific gravity; and S_m = measured specific gravity.

Specific gravity can be measured by the hydrostatic method in which the sample is weighed first in air and then in water (ASTM D 792-50). An alternative method is to use a tube containing a liquid of graded density. The sample will float at a level corresponding to its specific gravity (ASTM D 1505-57 T).

Use of Basic Factors: The three basic factors are controlled largely by the fabricator during molding through choice of resin and fabricating conditions. In many cases this control does not involve measuring the basic factors. It is sufficient to know how the processing steps must be varied to maximize the desired properties and what limitations are imposed by practical considerations of design and cost.

Where a particular crystallinity-dependent property is desired in a molding, better control is obtained by testing this property rather than the crystallinity which should be associated with it. When this is not possible, for example, because of difficulty in performing a life test, measurement of specific gravity alone often provides sufficient control of properties. For this method, the corresponding inherent polymer specific gravity is obtained from Fig. A and limits are set in accordance with allowable void content.

Likewise, it is usually sufficient to control void content by setting a minimum value for specific gravity. This minimum value depends on the end use of the part.

Because, as Table A shows, several factors influence specific gravity, it may be necessary in critical cases to measure crystallinity and void content directly. When this is done, however, the methods available have only limited precision. When crystallinity values are used, they should be considered subject to ±5 per cent crystallinity variation since they are relative only, and the calibration on which they are based has changed from time to time as methods of meas-

pressure and prevent leakage; thereafter, stress relaxation will be negligible.

Curves for tensile stress relaxation, Fig. 9, illustrate the rates at which tensile stress decays when the specimen is maintained at constant strain.

Compressive Recovery: Specimens which were successively compressed and allowed to recover from various percentages of strain indicate that they experience no work hardening, Fig. 10. Recovery of the specimen is nearly complete provided the original strain does not exceed the yield strain.

Recommendations for Gasket Design: To minimize creep and stress relaxation in gaskets, the following rules are recommended:

1. Use bolting loads less than 1000 psi for unconfined gaskets.
2. Specify the thinnest possible gasket that will accommodate flange roughness. Gaskets thicker than approximately 1/16 in. increase the amount and rate

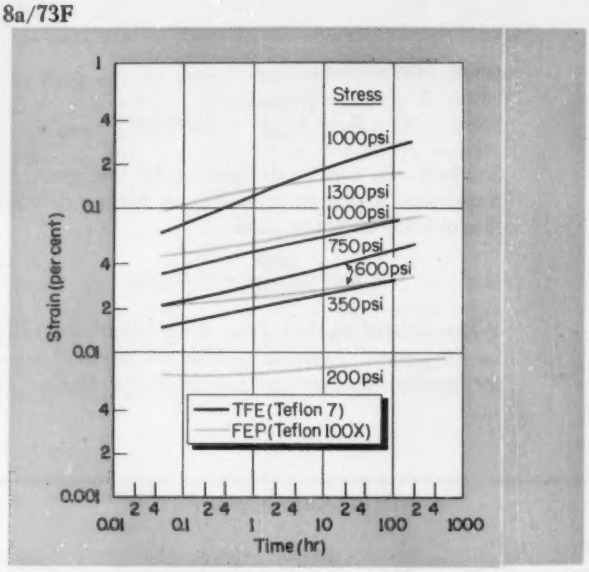

Fig. 8—Total deformation versus time under torsional load.

Effects of Processing (Cont'd)

urement have improved. Thus, the crystallinity versus specific gravity curve, Fig. A, is slightly different from those which have been published previously.

Relative precision of void content measurements is about ±0.5 per cent. Values below 0.5 per cent should be treated as indistinguishable, since in this region other factors, such as void distribution, become important.

Role of Processing: In processing TFE plastics, the basic fabricating steps each have a principal influence on one of the basic factors with secondary effects on other factors. Thus, cold forming primarily affects void content, sintering controls molecular weight, and cooling determines crystallinity.

One of the molding conditions that influences void content is indicated in Fig. B. Voids caused by insufficient consolidation of

Fig. D→

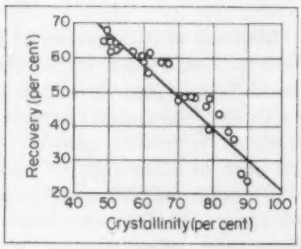

Fig. E→

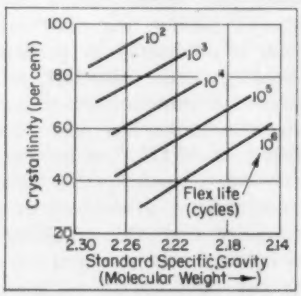

Fig. D—Relationship of recovery and crystallinity (ASTM D 1147-56 T, ¼-in. penetrator, 5-lb preload, 250-lb major load).

Fig. E—Flex-life parameters on a property map of crystallinity versus molecular weight (nonstandard test, 45 cycles per min, 180-degree bend).

Table A—Effect of Basic Factors on Specific Gravity

Basic Factor	Change in Specific Gravity as Basic Factor Increases
Molecular weight	Decreases
Crystallinity	Increases
Void content	Decreases

Table B—Effect of Cooling Rate on Relative Crystallinity

Cooling Rate (deg C/min)	Teflon 1* Crystallinity (per cent)	Teflon 6* Crystallinity (per cent)
Quenched in ice water	45	50
3	56	67
1	62	74
0.2	68	84

Crystallinity values are ±5 per cent.
*3-in. diam moldings preformed in ASTM test die (ASTM D 1457-56 T) at 5000 psi, sintered 1 hr at 716 ±9 F (380 ±5 C), cooled to 527 F (275 C). Thickness was between 0.060 in. and 0.125 in.

Table C—Effect of Annealing on Crystallinity

Annealing Time (hr)	Crystallinity (per cent) for annealing temperatures of: Teflon 1* 583F 306C	599F 315C	613F 323C	Teflon 6* 583F 306C	599F 315C	613F 323C
Ice quenched, then annealed†						
0.5	50	52	53	58	60	64
5	53	56	59	60	65	71
20	55	58	64	64	68	76
Cooled 1 deg C/min, then annealed						
0.5	59	60	60	78	78	78
5	59	61	63	78	78	79
20	60	63	65	78	78	81

*1½-in. diam x ⅛-in. thick moldings preformed at 5000 psi, sintered at 716 F (380 C) for 50 min, cooled to 572 F (300 C).
†Annealed in salt bath at stated temperature; quenched in ice water.

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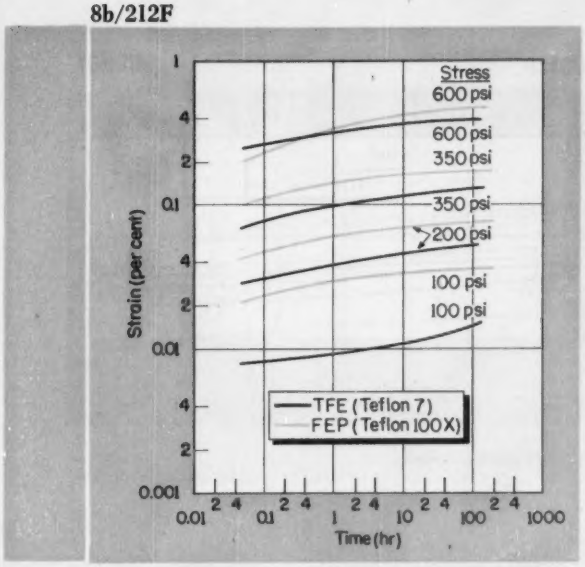

of stress relaxation.

3. Use reinforced Teflon resin compositions, such as 60 per cent Teflon resin and 40 per cent Fiberfrax fiber, for temperatures higher than 300 F.
4. Design a "self-contained" joint with captive gasket when such construction is desirable.

The three forces which act on a gasket that is bolted securely in position are: 1. Bolt load. 2. Hydrostatic end force. 3. Internal pressure. The procedure in the 1959 *ASME Boiler and Pressure Vessel Code*, Section VIII, Appendix II, may be used to calculate required bolt loadings for solid gaskets of TFE-fluorocarbon plastics. The method requires knowledge of the "yield stress" and the "gasket factor." Yield stress is the stress required to seat the gasket, or the minimum stress that will effect a seal against even slight fluid pressure. As internal pressure is applied to the vessel, the flanges tend to separate, thus lowering the effective stress on the gasket. Obviously, to maintain the seal requires

particles during preforming may be carried over into finished articles. Densities below 2.10 indicate a high void content for most purposes. For electrical and many chemical uses, a minimum density of 2.12 to 2.14 is needed. These values refer only to articles molded from TFE granular powders; higher figures will be obtained if Teflon 6 is used.

Particle size, shape, and porosity are also important in determining void content. Fig. B shows that Teflon 6, which has very small primary particles (about 0.25 micron), requires a preforming pressure of 500 psi to produce void-free moldings. For Teflon 1, a preforming pressure of 3000 psi is required to produce moldings with void content less than 1 per cent. Teflon 7 is intermediate between these resins and requires a pressure approximately one-half that for Teflon 1. Because Teflon 6 is not normally used for molding parts, Teflon 7 is used where the lowest possible void content is required.

Although void content is determined largely by particle characteristics and preforming conditions, sintering conditions can also have an effect. Sintering at too high or too low a temperature can increase void content.

Molecular weight after fabrication is determined primarily by initial molecular weight of the polymer. However, if sintering temperature exceeds approximately 734 F, a decrease in molecular weight may result. This change is illustrated by tests for specific gravity, which increases in direct proportion to a decrease in molecular weight. With standard specific gravity at 23 C ranging from 2.17 to 2.19 at 734 F, sintering from ½ to 3 hr at 824 F raised the specific gravity to 2.23 to 2.25.

Final crystallinity of a molding of TFE resin depends mainly upon initial molecular weight of the polymer, the rate of cooling of the sample, and, to a lesser extent, upon sintering conditions. The pronounced effect of molecular weight on crystallinity is shown in Tables B and C by comparing Teflon 1 (highest molecular weight resin) with Teflon 6. Moldings made under similar conditions are up to 15 per cent less crystalline in Teflon 1 than in Teflon 6. The level of crystallinity of moldings made from either resin can be changed as much as 25 per cent by varying either the cooling rate or the annealing conditions for that particular resin.

Although final crystallinity is relatively unaffected by normal sintering conditions, indirect effects are evidenced for short-time, low-temperature sintering conditions, or for high sintering temperatures where degradation can occur.

The wide variation in properties of TFE plastics as a result of level of crystallinity may create doubts about permanence of those properties. Fortunately, because of the extremely high molecular weight of these resins, appreciable changes in crystallinity do not take place except at high temperatures. Teflon 1, for instance, experiences less than 10 per cent change in tensile strength and elongation after aging 40 days at 545 F.

Influence of Basic Factors: Certain properties of a molding depend on only one of the three basic factors. Dielectric strength at constant thickness, for example, increases as void content decreases, Fig. C. Flexural modulus, an indication of stiffness, increases by a factor of five as crystallinity varies from 50 to 90 per cent with a void content of 0 to 2

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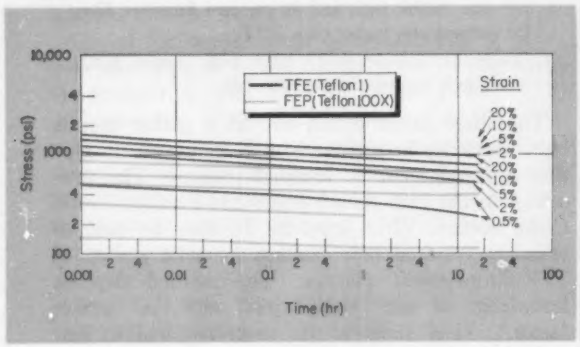

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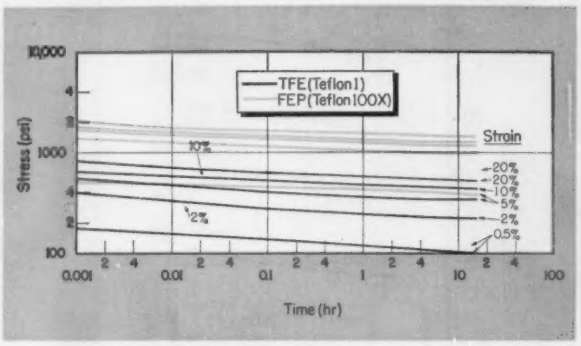


Fig. 9—Tensile stress relaxation under constant strain.

Effects of Processing (Cont'd)

per cent.

Recovery, however, decreases with increasing crystallinity, Fig. D. One property must frequently be balanced against another, as in the case of stiffness and recovery, with the proper choice being determined by needs of the application.

Most properties are controlled by more than one basic factor. Fig. E illustrates the effect of both molecular weight and crystallinity on flex life. Flex life increases roughly 100-fold as molecular weight increases or as crystallinity decreases.

Table D indicates the relative effects of all three basic factors on a number of properties, many of which depend upon the level of crystallinity. In an extreme case where void content was 6 per cent, permeability to gases increased 1000-fold. Relatively few properties depend directly upon molecular weight, but this does not mean that molecular weight is unimportant. Crystallization rates, and therefore final levels of crystallinity, depend on molecular weight. Molecular weight thus exerts its greatest influence on properties through crystallinity.

Practical Control of Properties: Theoretically, certain properties of TFE plastics can be controlled over a wide range by varying the crystallinity. In practice, however, part design and manufacturing cost dictate levels of crystallinity which can be attained.

To produce parts of TFE resins with low crystallinity, heat from sintering or annealing must be removed by rapid cooling. However, this is not feasible for sections thicker than $\frac{1}{8}$ in. because TFE resins are poor conductors of heat. When a thick section is cooled rapidly, low-crystallinity material is produced near the cooled surface, but a higher crystallinity is created in the center of the piece.

High crystallinity can be produced throughout thick sections by slow cooling, a time-consuming process which increases cost of manufacturing.

In sections thinner than $\frac{1}{8}$ in., both low and high crystallinity levels are possible because the difficulty of removing heat rapidly is lessened. For instance, crystallinity of skived tape can be adjusted, if desired, by an annealing step after the skiving operation. Although this additional step is usually not required, it can be done at added cost.

In most postforming operations where a part is heated above 620 F and placed in a cold mold, low crystallinity is obtained by cooling the mold to remove heat rapidly from the part. Because increased flex life is obtained with lower crystallinity levels, a cooled mold is particularly desirable when molding diaphragms for valves and other mechanisms.

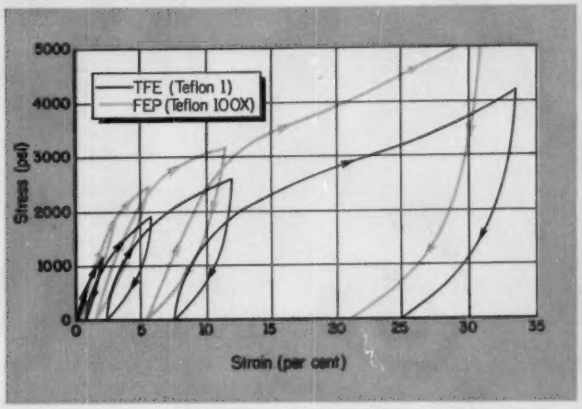
In most applications a low-crys-

Table D—Maximum Change in Properties Caused by Increasing Each Basic Factor

Physical Property	Molecular Weight	Crystallinity	Void Content
Flex fatigue life	+100-fold	−100-fold	−1000-fold
Compressive stress at 1% deformation	0	+50%	0
Compressibility	0	−50%	No data
Recovery	0	−70%	No data
Permeability to carbon dioxide	0	−30-fold	+1000-fold
Flexural modulus	0	+ 5-fold	−30%
Hardness: Durometer	0	+20%	No data
Rockwell	0	−20%	−30%
Scleroscope	0	−70%	−10%
Tensile impact strength	0	−15-fold	−80%
Dielectric strength	0	0	−70%
Proportional limit	0	+80%	−20%
Yield stress	0	+15%	−20%
Yield strain	0	−15-fold	0
Tensile strength	+25%	−50%	−50%
Ultimate strength	+50%	−70%	−50%
Ultimate elongation	−20%	+100%*	−80%

*Reaches maximum at 85 per cent crystallinity.

10a/73F



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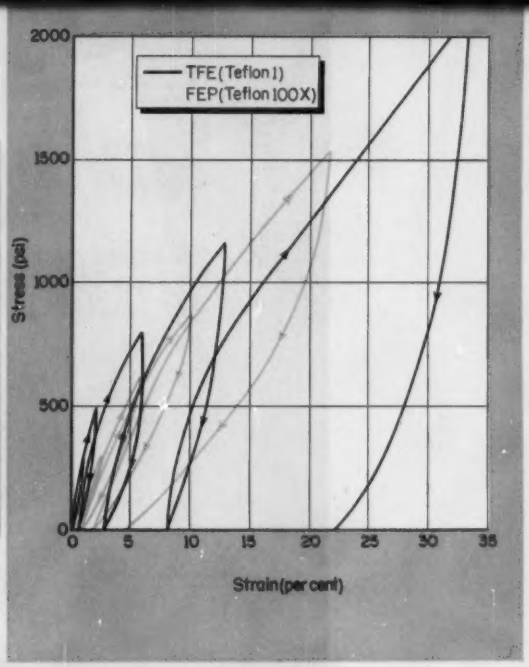


Fig. 10—Compressive stress recovery. Data for 1, 2, and 5 per cent are for repeated loadings; data for 5 and 10 per cent are for single loadings.

tallinity material is desirable. Flex fatigue life, tensile impact strength, and elongation at yield are markedly improved by low crystallinity. Only flexural modulus, impermeability, and ultimate elongation (not elongation at yield) are appreciably improved with increased crystallinities.

Normally, Teflon 1 and Teflon 7 are molded or ram extruded. Paste extrusion, a process in which an intimate mixture of resin and extrusion aid is extruded through a die, is possible only for Teflon 6. Cooling rates and corresponding crystallinities are listed in Table E for various fabricating techniques.

For design purposes, the recommended range of crystallinity is 50 to 75 per cent. While it is occasionally possible under special processing conditions to obtain higher or lower crystallinity values, design of parts should be based on physical properties obtained within this range and preferably within the range sugested by Table E.

Table E—Practical Crystallinity Ranges

Method of Fabrication	Range of Cooling Rates	Crystallinity (per cent)
Molding*	Quenching, to cooling at 45 F per hr	49 to 57
Ram extrusion	Quenching, to cooling at 45 F per hr	50 to 57
Paste extrusion†	Quenching	50 to 55

*Coining is a molding technique for cooling rapidly under pressure.
†Only sections thinner than 0.080 in. are paste-extruded.

Table 4—Values for Calculation of Required Gasket Loads

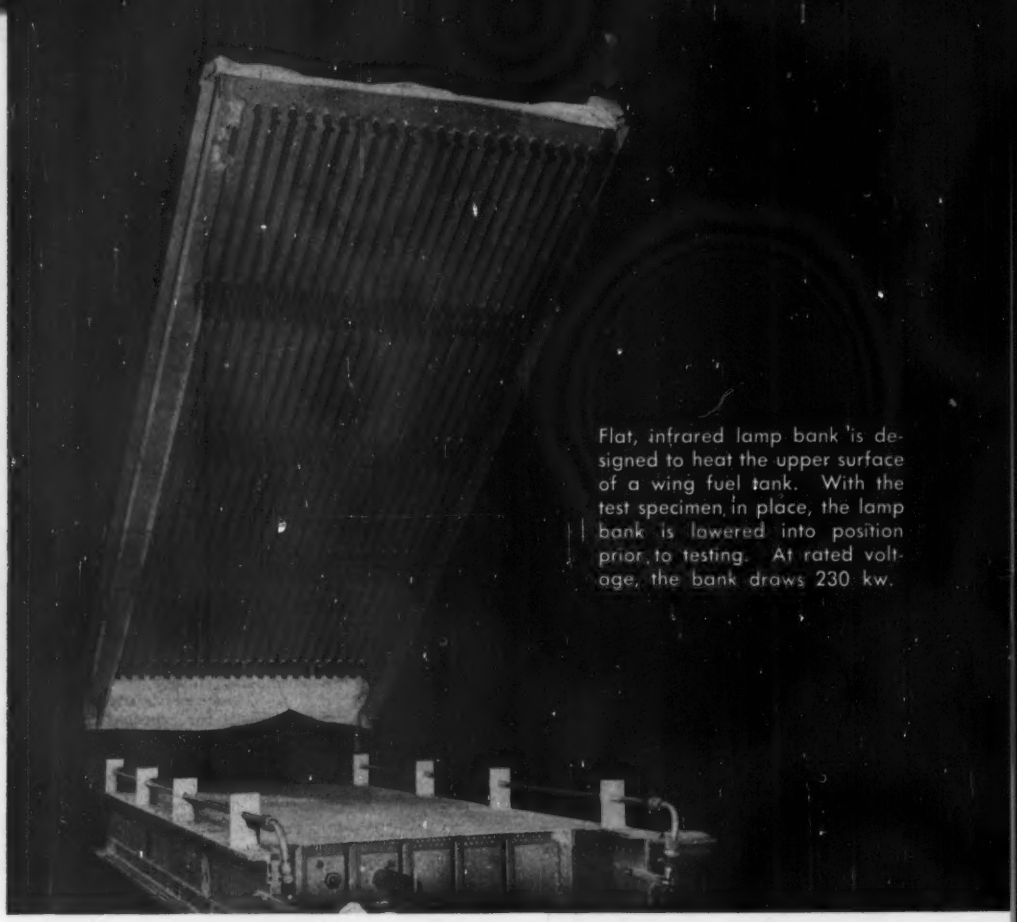
TFE Thickness (in.)	Yield Stress (psi)	Gasket Factor
⅛	1600	2.00
1/16	2000	2.50
1/32	3700	2.75
1/64	6500	3.50

that resultant stress on the gasket exceed the internal pressure. The minimum required ratio of these pressures is called the gasket factor.

Proved values for yield stress and gasket factor are listed in Table 4 for solid TFE resins. With these values, the necessary gasket load can be calculated from Formula UA-47-2 given in the above ASME reference. Required gasket load can then be converted to bolt load by standard mechanical engineering calculations (See *Mechanical Engineers' Handbook*, Marks, Sixth Edition, Section 3, p. 48).

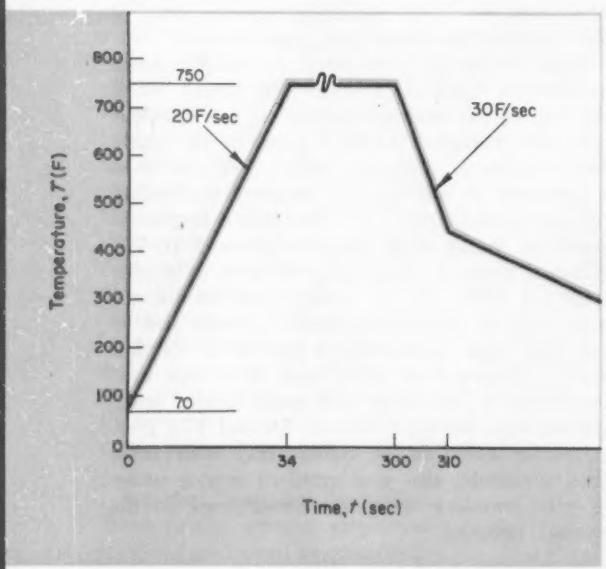
Gaskets made by enveloping asbestos or rubber in molded TFE resin are widely used for flanged connections to glass-lined reaction vessels and to glass-lined pipe. Spiral-wound gaskets of stainless steel and Teflon resin sheet stock have been used successfully in both large and small flanged joints requiring high bolting pressures. Molded TFE plastics, either alone or in combination with other gasket materials, also give excellent service under the most corrosive conditions encountered in the chemical industry.

Next article will conclude this two-part series on TFE and FEP resins by covering thermal and electrical characteristics, fatigue, impact, and wear.



Flat, infrared lamp bank is designed to heat the upper surface of a wing fuel tank. With the test specimen in place, the lamp bank is lowered into position prior to testing. At rated voltage, the bank draws 230 kw.

How to design radiant heating equipment



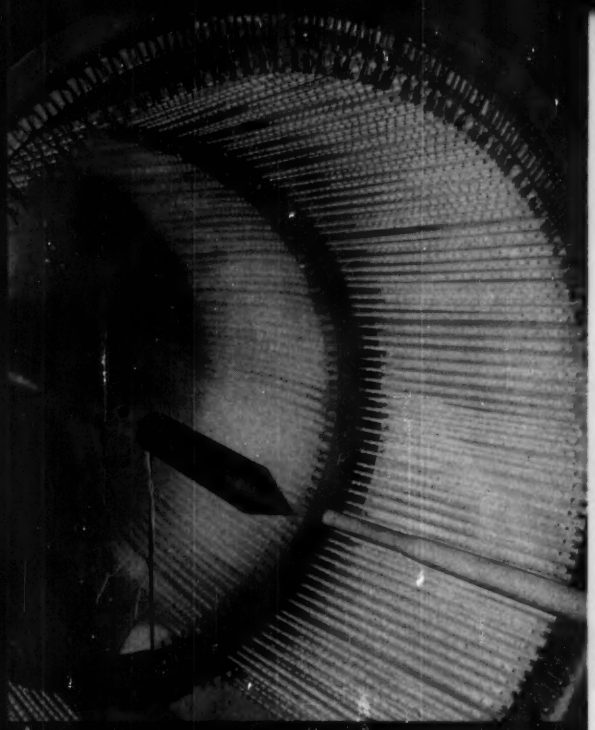
1 Temperature response of manned interceptor skin for typical mission.

SEVERE thermal conditions experienced by some of today's structures and components have created a need for thorough evaluation in design and prototype stages. Temperatures and heat rates encountered by high-speed aircraft are typical of the conditions that must be reproduced in the laboratory.

However, special environmental test facilities may be required for simulating high heat-rate conditions on a test specimen. High-temperature apparatus designed to produce a heat rate of 20 F per sec up to 750 F is described in this article. These conditions occur during the fast climb of a manned interceptor. Unmanned interceptors may reach 3500 F with heat rates exceeding 500 F per sec.

Basic methods for producing heat rates include all the known heat transfer processes: Conduction, convection, and radiation. Conduction and convection, however, are not suitable because of the extremely sensitive control needed when programming the required high-energy fluxes and heat rates. Induction heating is also possible but is usually prohibitive from the standpoint of cost.

Radiant heating lends itself easily to the problem of producing high energy fluxes and good sys-



A 500 kw circular lamp bank is used for heating sections of cylindrical specimens up to 3.5 ft in diameter. Reflectors are specular-finished aluminum sheet. A missile model is shown ready for test. The protruding tube in the foreground is a CO_2 gas nozzle which provides cooling for the nose section.

Testing at High Heat Rates

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for simulating extreme temperature rises.

tem response. Designing a radiant-heating lamp bank requires determination of:

1. Power to be absorbed by test specimen.
2. Type of heating element.
3. Type of reflector.
4. Distance between lamps.
5. Distance between lamps and specimen.
6. Method of cooling.
7. Method of measuring deflection.

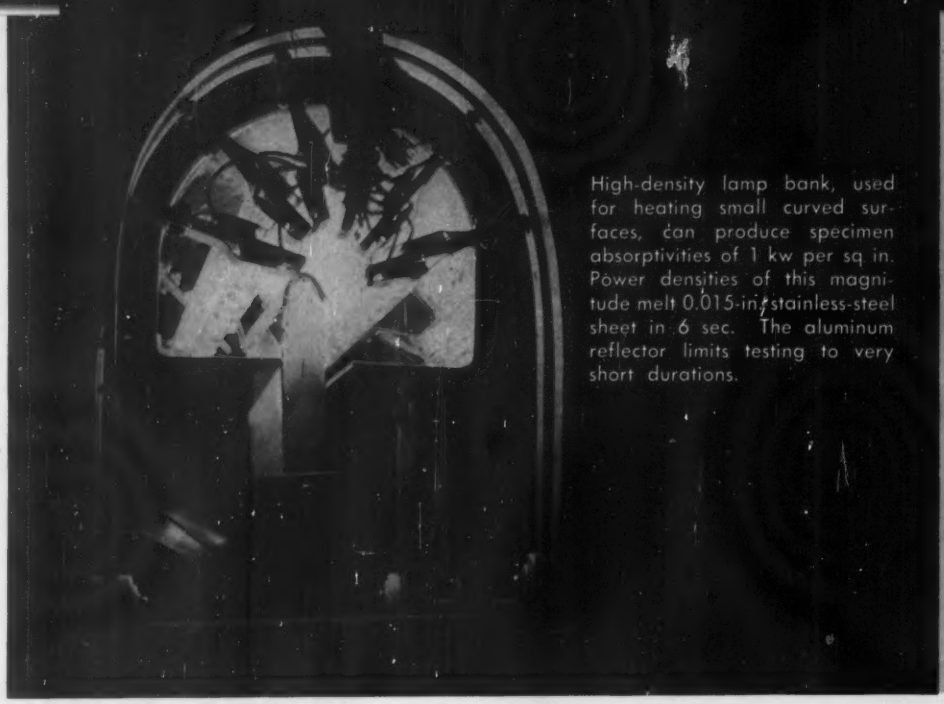
Power Absorbed by Specimen: Fig. 1 is a time-temperature curve for a section of wing skin on a hypothetical manned interceptor. The skin required for such a vehicle would probably be a stainless-steel honeycomb sandwich. Before the energy absorbed by the skin is determined, an equivalent thickness must be calculated. Because it must react thermally like the honeycomb structure, the equivalent skin is considered to be a solid sheet of the same material as the honeycomb skin. An equivalent skin of Type 301 stainless steel, 0.040 in. thick, is used.

Energy flux that will be required is proportional to specific heat of the steel, which in turn is proportional to temperature. Since the highest flux will

Nomenclature

A = Area of specimen, sq in.
a = Unit length of specimen heated by 1-in. of lamp, in.
C_p = Specific heat of specimen surface, Btu/lb-deg F
d = Distance between lamp centers, in.
F = Conversion constant, kw-hr/Btu-sq in.
$= 2.04 \times 10^{-6}$
h_c = Convection heat transfer coefficient
h_r = Radiation heat transfer coefficient
K = Conversion constant, kw-sec/Btu
$= 1.055$
Q = Total energy flux required at specimen, kw per sq in.
Q_l = Energy flux developed at lamps, kw per sq in.
T_a = Temperature of surrounding medium, Rankine
T_s = Temperature of heated specimen, Rankine
ΔT = Temperature rise, F
t = Time, sec
W = Weight of specimen, lb
ε = Emissivity of specimen surface
η = Efficiency of lamp bank

Testing at High Heat Rates



High-density lamp bank, used for heating small curved surfaces, can produce specimen absorptivities of 1 kw per sq in. Power densities of this magnitude melt 0.015-in. stainless-steel sheet in 6 sec. The aluminum reflector limits testing to very short durations.

have to be produced at the maximum temperature in the heating cycle, maximum power density will be needed at 750 F where skin temperature must be raised 20 F per sec.

Energy losses at the specimen will occur and must be included. It is assumed that the specimen is well insulated and that little energy is lost by conduction to surrounding jig work. However, convection and reradiation losses must be accounted for.

Therefore, the total energy required equals energy the specimen must absorb plus energy loss due to convection plus energy loss due to radiation, or

$$Q = C_p K \frac{\Delta T}{t} \frac{W}{A} + h_c F(T_s - T_a) + h_r F(T_s - T_a) \quad \ldots\ldots (1)$$

where

$$h_c = 0.38(T_s - T_a)^{0.25} \quad (2)$$

$$h_r = \frac{0.173\varepsilon \left[\left(\frac{T_s}{100} \right)^4 - \left(\frac{T_a}{100} \right)^4 \right]}{T_s - T_a} \quad (3)$$

Substituting Equations 2 and 3 into Equation 1, and simplifying,

$$Q = C_p K \frac{\Delta T}{t} \frac{W}{A} + 3.53 \times 10^{-7} \left\{ 2.2(T_s - T_a)^{1.25} + \varepsilon \left[\left(\frac{T_s}{100} \right)^4 - \left(\frac{T_a}{100} \right)^4 \right] \right\} \quad (4)$$

Values to substitute into Equation 4 are: $C_p = 0.136$; $\Delta T/t = 20$; $W/A = 0.04 \times 0.284$, which is equivalent skin thickness times density; $T_s = 1210$; $T_a = 520$.

Ideally, the specimen should absorb as much of the energy exposed to it as possible. To increase absorption, the specimen can be coated with a high-emissivity material. A mixture of black cobaltic oxide and alcohol has proved to be an excellent coating. The oxide is held in suspension by the alcohol and is easily brushed over the surface of the specimen. The emissivity of cobaltic oxide has been measured in the infrared range between 900 and 2300 millimicrons. In this range, emissivity varies between 91 and 94 per cent. A value of $\varepsilon = 0.925$ is used in Equation 4.

Then, substituting into Equation 4,

$$Q = 0.136(1.055)(20)(0.04 \times 0.284) + 3.53 \times 10^{-7}(7790 + 20670)$$

$$= 0.0326 + 0.00949$$

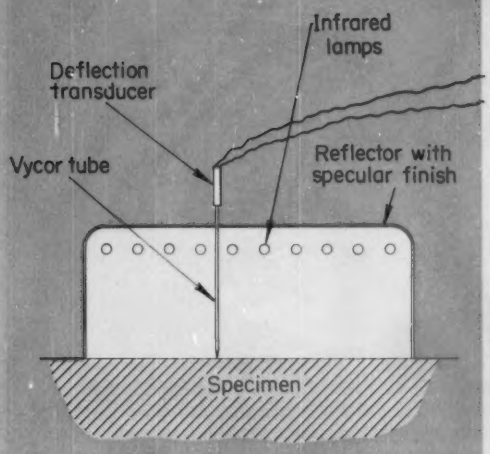
$$= 0.0421 \text{ kw per sq in.}$$

Thus, 0.0421 kw per sq in. represents the total energy required at the specimen. It includes power to be absorbed by the test specimen and the convection and radiation losses.

Heating Element: Some commercially available radiant heating sources are: Nichrome wire elements, silica carbide elements, chromium-steel rod-type elements, and quartz-tube tungsten-filament lamps. Factors to consider when selecting a radiant heat element are:

1. Response time to reach maximum temperature.
2. Rate of element oxidation.
3. Service life.
4. Power dissipated per unit length of element.

The tungsten-filament quartz lamp is selected because it adequately fulfills the above considerations. The lamp operates at the highest temperatures—near 4000 F at rated voltage. It radiates 85 per cent of its input energy compared to 50-60 per cent for radiating devices which operate at lower temperatures. At rated voltage the quartz tube will reach



2 Lamp bank with reflector over specimen.

80 per cent of maximum output almost instantly, where 50 seconds is average for other radiant-heating elements. The cool-down period is equally fast.

The tubular quartz lamp has a tube diameter of approximately $\frac{3}{8}$ in. and comes in heated lengths of 5, 10, 25, and 50 in. The lamp will operate satisfactorily under extreme thermal shock conditions such as direct contact with water and even with ice when at full power.

At rated voltage the lamp will expend 100 w per linear inch of filament. However, this value can be reduced or increased by varying the applied voltage. Maximum overvoltage that can be applied is 225 per cent, above which the filament almost instantly melts. At 225 per cent of rated voltage, expended wattage is increased to 350 per cent, and 350 w per linear inch of filament can be expected.

The only operating limitation besides keeping the applied voltage under 225 per cent of rated voltage is not to exceed 650 F at the ends of the tube where the quartz and a lead wire are sealed. If temperature exceeds 650 F, the wire will expand and crack the quartz.

Energy is dissipated by a quartz lamp at rated voltage at a frequency of 1140 millimicrons. This frequency for the cobaltic-oxide coating previously discussed corresponds to an emissivity of 92.5 per cent. Thus, the coating on the specimen should absorb 92.5 per cent of the total energy radiated, which is how the value of ε was determined.

Reflector Material and Lamp Efficiency: The quartz lamps, when positioned over the specimen, will be backed with a reflector, Fig. 2. If the reflector edges come down and almost touch the specimen, lamp bank efficiency will be high—approximately 80 per cent—providing a good reflector material is used. Aluminum sheet which has a "bright" or specular finish makes a good reflector for short-duration tests at high temperatures or for soak tests limited to 850 F. This type of sheet has an emissivity of about 0.08 at 1140 millimicrons and can be expected to reflect 92 per cent of exposed radiation at that frequency.

For soak tests at high temperatures, reflectors can be made of stainless-steel sheet that has been plated, ceramic baked, or vacuum metallized with any of the noble metals. Because of cost, this type of reflector is used only when temperature limits the use of aluminum sheet.

Lamp Spacing: As previously determined, the lamp bank must be capable of producing specimen absorption of 0.0421 kw per sq in. However, in the plane of the lamps, a greater flux must be produced because of incomplete coating absorption, losses in the reflector material, and efficiency of the lamp bank configuration. With these quantities known ($Q = 0.0421$, $\varepsilon = 0.925$, $\eta = 0.80$), flux that must be developed at the lamps can be calculated from

$$Q_l = \frac{Q}{\varepsilon \eta} \tag{6}$$

Substituting,

$$Q_l = \frac{0.0421}{0.925(0.80)}$$

$$= 0.0569 \text{ kw per sq in., or } 56.9 \text{ w per sq in.}$$

Since the lamps expend 100 w per linear inch at rated voltage, lamp spacing can now be calculated. Fig. 3 shows a plan view of lamps over a small section of the specimen. The area which 1 in. of lamp must heat is $a \times d$. The lamp network must produce 56.9 w per sq in. With $a = 1$ in., lamp spacing is then

$$\frac{100 \text{ watts}}{ad} = 56.9 \text{ w per sq in.}$$

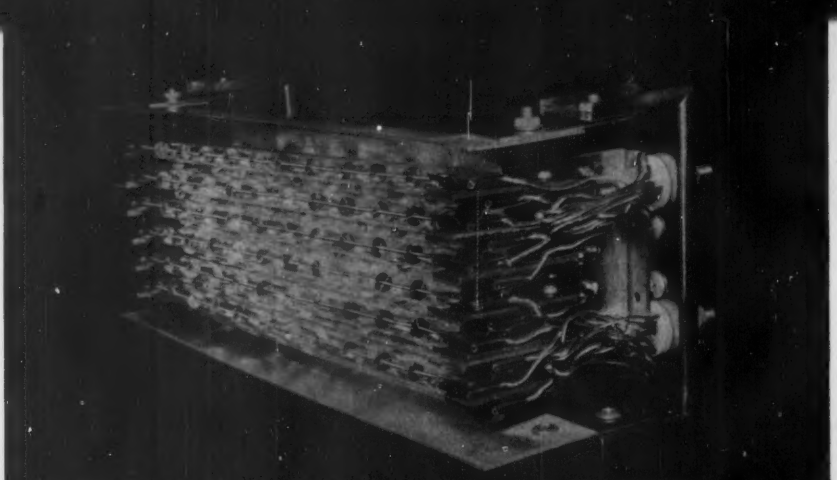
$$d = \frac{100}{1.0(56.9)} = 1.758 \text{ in.}$$

The lamps would probably be placed 1.75 in. apart for convenience of construction. The calculated 1.758 in. is conservative since calculations were based on heating the entire mass at a rate of 20 F per sec and not the entire skin.

Distance from Lamps to Specimen: The lamp bank required to test the wing section is now closely defined. However, another consideration must be taken into account. If the lamps are too close to the specimen, hot spots directly below the lamps will develop, and a sinusoidal distribution of temperature will result.

Several factors, such as linear power density of the lamps, emissivity of the specimen, thermal diffusivity of the surrounding atmosphere, and lamp spacing, determine the distance between lamps and specimen. A conservative distance to use, which has been proved by tests, is three times lamp spacing.

Testing at High Heat Rates

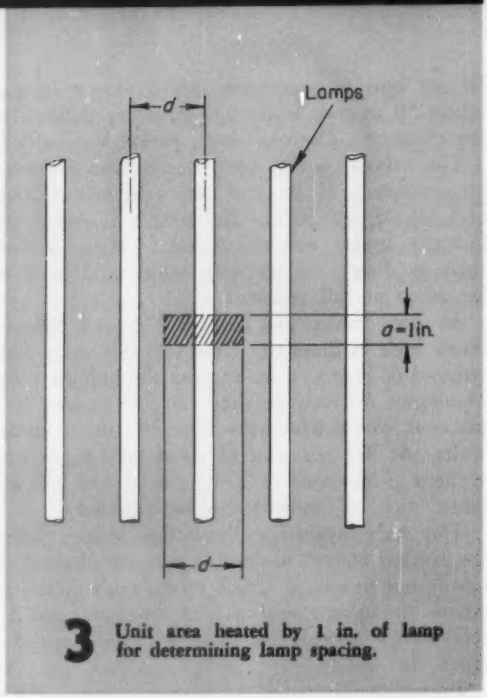


Specimen absorptivities of 1 kw per sq in. have been obtained with this type of lamp bank. To overcome the limitations of an aluminum reflector, a steel reflector coated with ceramic and vacuum-metalized with gold is used for high-temperature operation. Large, flat surfaces are tested by grouping several lamp banks into a bigger unit. The high power density output is suitable for testing most of the heated areas on unmanned interceptors, missiles, and re-entry vehicles. However, the lamp bank would not be used for extremely hot stagnation areas such as the vertex of a nose cone.

For a lamp spacing of 1.75 in., the distance from lamps to specimen would be 5.25 in.

Cooling Provisions: A lamp bank designed as outlined has adequate facility for heating the specimen in accordance with Fig. 1. However, the cooling side of the curve requires a cooling device, since reradiation of the specimen and convection heat transfer to the surrounding medium are not sufficient to give the decreasing rate of 30 F per sec.

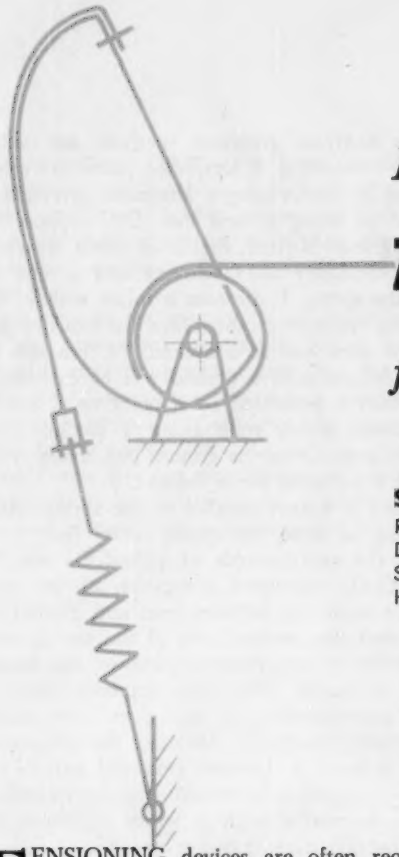
Cooling can be accomplished by expanding a cool, compressed gas over the heated surface. Mass flow of the cooling medium should be sufficiently large that the surface is cooled faster than required. When the specimen is cooler than it should be, the lamp-bank power controller activates the lamps to bring the temperature back to the curve. Power to the lamps is then reduced, and the cooling device continues to drive the surface temperature down until the lamps burn brightly. This modulating cycle of bright to dim is repeated until the end of test.



3 Unit area heated by 1 in. of lamp for determining lamp spacing.

Measuring Deflection: If deflections of the heated surface are to be measured, Vycor extension tubes connected to deflection transducers minimize error due to thermal expansion. A Vycor tube of approximately $\frac{3}{8}$ in. diameter is inserted through the reflector and between the lamps, Fig. 2. Both emissivity in the infrared range and coefficient of thermal expansion are extremely low for Vycor glass. Such an extension tube can be used up to about 1500 F with negligible error. For higher temperatures, a ceramic cap can be placed on the tip of the tube to separate it from the heated specimen.

If care is exercised in cooling exposed jig areas, which otherwise would become overheated, the same methods that have been outlined for lamp-bank design can be used for tests requiring maximum temperatures greater than 750 F and heat rates which exceed 20 F per sec.



Designing a Zero-Gradient Spring System *for constant-tension service*

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TENSIONING devices are often required in mechanical systems to maintain an external force on moving parts over a given range of displacement. If force variation is not critical, this requirement can be fulfilled simply in a number of ways. However, when tension must remain constant, some form of zero-gradient device is usually necessary. Typical application for such devices includes counterbalancing, stacking and feeding, and tensioning of flexible drive elements such as belts and chains.

Two types of zero-gradient devices commonly used to perform these functions are counterweights and constant-force spring elements.[1] Another effective answer to the problem is offered by the combination of a cam and an extension spring. However, such systems involve complex dimensional relationships that are difficult to resolve by conventional methods of analysis. This article presents a simplified approach for finding the right combination of cam profile and spring proportions to meet specific operating requirements.

Basic Concepts

Suppose that the requirement of a constant force acting through some linear displacement can be transformed into a torque acting through a corresponding angular displacement about some fixed point. Then, the method presented here is based on the concept that an extension spring can be combined with a variable moment arm about the fixed point, so that the product of spring force and moment arm is always equal to the required external torque throughout the range of operation.[2]

To help clarify this concept, consider the tensioning arrangement for a chain-conveyor carriage shown schematically in Fig. 1. The sprocket carriage is to be subjected to a constant tensile force, F, over its operating range, d. A cable is fastened to the carriage and runs over a sheave of radius r. Thus, the force requirement of the tensioning system is transformed into a torque, $M = Fr$.

In this tensioning system, one end of a flexible band is attached to an extension spring and the other end is fastened to a cam integral with the sheave. As the sheave rotates through its working range, length of the spring changes. Spring deflection is accompanied by a linearly proportional change in the force it exerts.

If spring and cam are designed so that the product of spring force P and distance h equals torque M throughout the range of displacement, the system is in equilibrium. Synthesis of such a spring-cam combination is the objective of the method presented here.

Design conditions for the spring-cam system are:

1. The flexible member must be strong enough to withstand maximum spring force and flexible enough to follow the cam profile faithfully. Typical elements which are suitable include chain, metal band, rope, and cable.

[1]References are tabulated at end of article.

2. The device must be used in tension (the only load a flexible member can transmit), implying use of extension-type coil springs. This type of spring is generally preferred because it automatically aligns its geometrical axis with the direction of spring force.

3. Cam profile must be continuous without any reversals in curvature (no concavities in profile) to permit the band to make contact with all cam contour co-ordinates.

System Relationships

In a typical spring-cam unit, Fig. 2, a spring of free length L with spring gradient k is fastened to a fixed position, A. The other end of the spring is attached to a cam at position S_0 which is the point of tangency between spring center line and cam surface. Variation of moment as a function of cam displacement ϕ will now be examined. In the first position, defined by angle ϕ_1, the spring is extended to length l_1 and the moment, M, developed by spring force about cam pivot O is

$$M_1 = (l_1 - L)kh_1$$

When the cam moves to angular position ϕ_2, the spring elongates further and

$$M_2 = (l_2 - L)kh_2 = (l' + Q_{ST} - L)kh_2$$

where length l_2 is the sum of the distance, l', between point A and new point of tangency T, and the arc length, Q_{ST}, from point S to point T. For each succeeding cam position, the length of the spring must be re-established in a similar manner. For this analysis, graphical methods are tedious and time-consuming. A simplified procedure can be developed by introducing a kinematic inversion.

Instead of fixing ground link, OA, suppose that the spring itself is fixed, Fig. 3. In effect, the spring is made stationary and both cam and ground link roll up the spring. If the cam is rolled without slipping along the spring center line, the locus of point O on the cam will be a cycloid, Y_C. (In this discussion, definition of a cycloid will be extended to include curves generated by a point on a body of any contour which rolls along a straight line.) Similarly, point O on the ground link traces cycloid Y_G which is a circular arc of radius OA.

If a line is drawn parallel to the spring axis at a distance, h_i, from the spring center line, it will intersect the two cycloids at points O_C and O_G. Length O_CO_G represents elongation of the spring when the angle, ϕ_i, between cam and ground link is such that the moment arm of the spring equals h_i. Since the spring gradient is known, the moment can be calculated. With this approach then, the moment corresponding to any given cam position can be readily computed. Although the independent variable is angle ϕ, between cam and ground link, analysis is simplified by substituting the variable, h, and then measuring angle ϕ, which is defined by a given value of h, directly on the layout.

Design Approach

To design a cam-spring system, the previous tech-

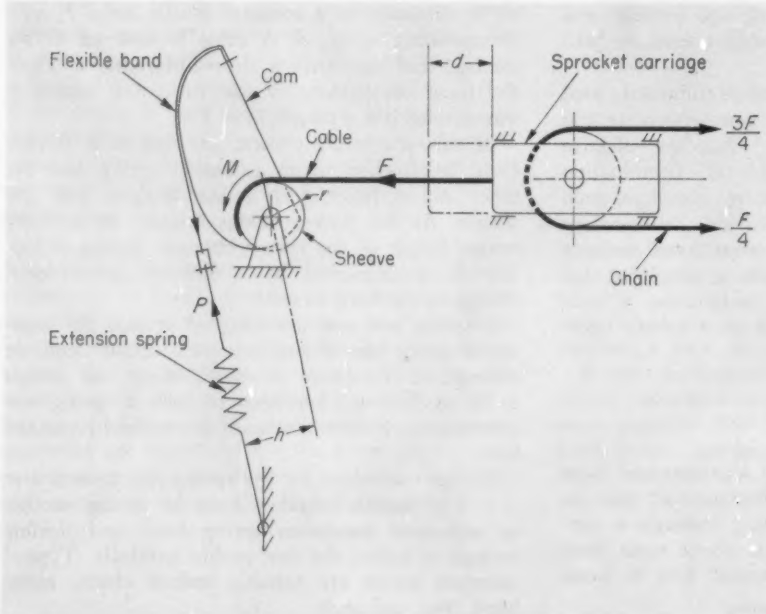


Fig. 1—Application of a zero-gradient tensioning device to maintain constant tension on a conveyor chain. Spring and cam are so proportioned that tension force remains constant and unaffected by movement of carriage.

nique need merely be inverted. From given moment-displacement relationships, a suitable combination of cam profile and spring parameters is developed. For a zero-gradient system, moment is constant and the moment-displacement curve is obviously a horizontal line.

First step in the solution is to construct proper cam and ground-link cycloids. In Fig. 4, the X-axis represents the spring center line. For the ground-link cycloid, assume that the link is infinitely long. Hence, this cycloid is a straight line perpendicular to the spring center line, and may be represented by the Y-axis. For any moment arm, h, spring elongation l must be such that the product of spring force and moment arm is the required external moment, M. Thus,

$$M = h(lk) \tag{1}$$

or, by rearranging terms,

$$hl = \frac{M}{k} = c^2 \tag{2}$$

where c is a constant that represents a size parameter. Equation 2 is the expression for a rectangular hyperbola and represents the theoretical cycloid of the cam. Actually, the cam cycloid is not a hyperbola because the ground link has finite length and its cycloid, Y_G, is a circular arc rather than a straight line. As a result, the hyperbola must be laid out on a combinaion co-ordinate system in which one set of co-ordinates is orthogonal and the other curvilinear. Dotted cycloid Y_C in Fig. 4 shows the hyperbola corrected for this condition. Next step is to construct a cam with such profile that fixed point O will generate cycloid Y_C when the cam is rolled along the X-axis.

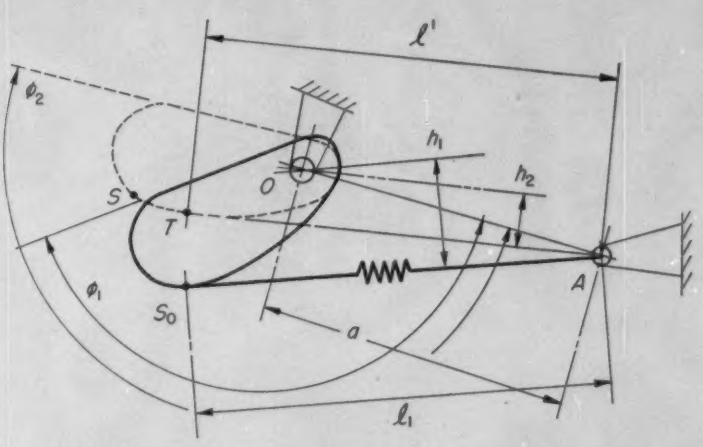


Fig. 2—Method for calculating moment of a cam-spring system as a function of cam displacement ϕ. For each cam position, an incremental length of the cam's curved periphery, arc length ST, must be remeasured.

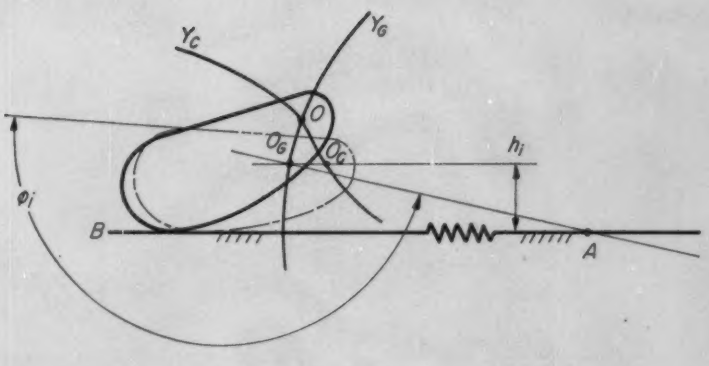


Fig. 3—Introduction of a kinematic inversion to simplify analysis of moment-displacement relationships for system in Fig. 2. A plot of cam and ground-link cycloids, Y_C and Y_G, makes it possible to measure spring elongation as a straight length, O_GO_G.

ZERO-GRADIENT SPRING SYSTEM

Graphical construction of a cam profile which corresponds to the derived cycloids, Y_C and Y_G, is shown in Fig. 5. Line *AB* in this layout represents the *X*-axis. In this solution, radius *a*, which defines cycloid Y_G, has been arbitrarily set at 6.00 *c*, where *c* is the size parameter previously defined by Equation 2.

By definition, line *AB* is the locus of instantaneous centers of cycloid Y_C. In addition, the instantaneous center of any given point on cycloid Y_C must lie on the normal to the cycloid at that point. If normals are erected to the curve, they will intersect the base line, *AB*, at points which control cam profile development. Construction of these normals can be accomplished graphically. However, the resulting cam profile is sensitive to the accuracy with which these normals are laid out, so an analytical approach is advisable.

In Fig. 4, let point O_C on cycloid Y_C be defined by the generalized Cartesian co-ordinates, (x, y). If w is the distance between the *Y*-axis and point O_G,

$$x = l + w$$

$$y = h$$

Also, if cycloid Y_G is a circular arc of radius, *a*, then

$$w = a - (a^2 - y^2)^{1/2}$$

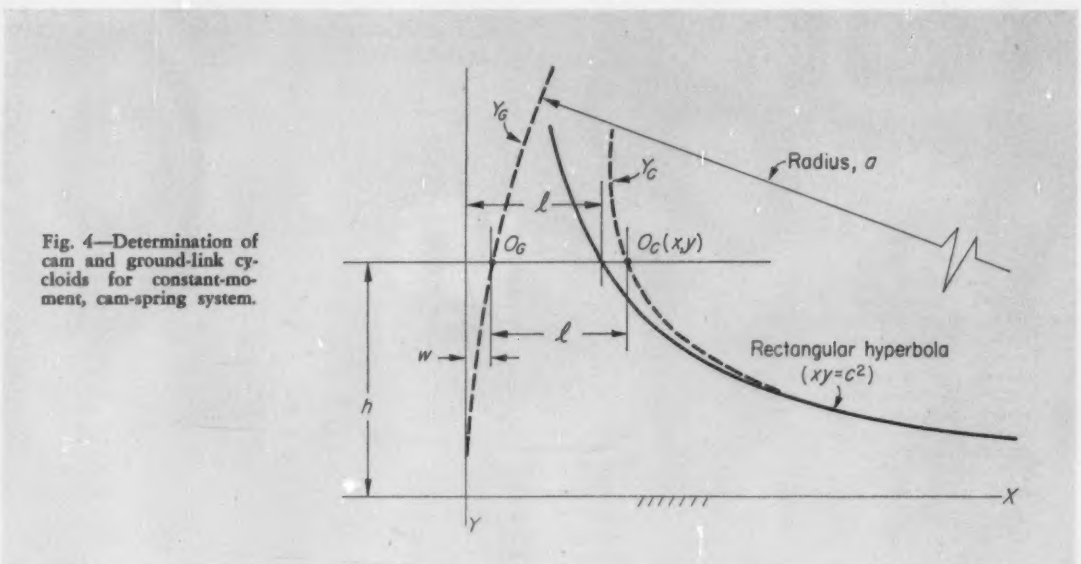
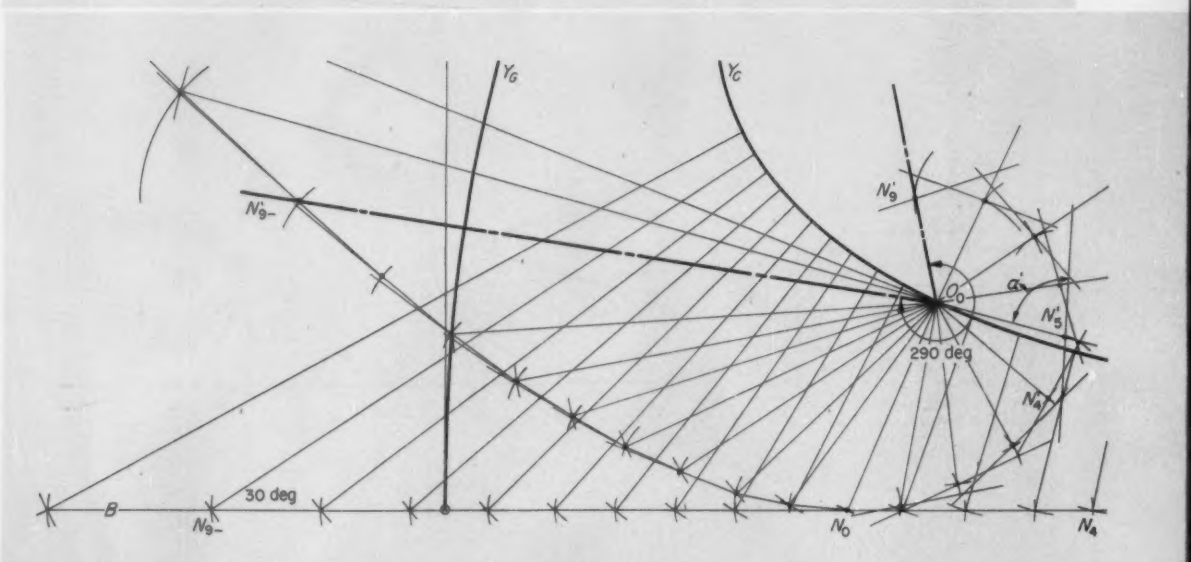


Fig. 4—Determination of cam and ground-link cycloids for constant-moment, cam-spring system.



From Equation 2

$$l = \frac{c^2}{h} = \frac{c^2}{y}$$

Substituting these equivalents for w and l into the expression for x gives the equation for cycloid Y_C:

$$x = \frac{c^2}{y} + a - (a^2 - y^2)^{1/2} \qquad (3)$$

If this equation is differentiated with respect to x, the negative reciprocal of dy/dx gives inclination, α, of a normal passing through point y. Performing this operation,

$$a = \frac{c^2}{y^2} - \frac{y}{(a^2 - y^2)^{1/2}} \qquad (4)$$

Values for constants c and a will be determined later.

After a convenient number of normals to cycloid Y_C are erected, Fig. 5, the cam profile is determined graphically.

Some point, O_0, on cycloid Y_C is selected to be the cam pole. Since each normal is an element of the cam, normals are successively referred back to the cam pole so that all O points coincide at point O_0 and all base line increments equal corresponding arc lengths on the cam profile.

For example, consider normal O_5N_5. If this line is displaced so that point O_5 coincides with point O_0, and line N_4N_5 equals arc, $N'_4N'_5$, point N'_5 is a point on the cam profile. Lines drawn through the N' points at angle $\alpha' = \alpha$, are tangents to the cam profile at their respective N' points. A smooth curve drawn through these points establishes the required cam profile.

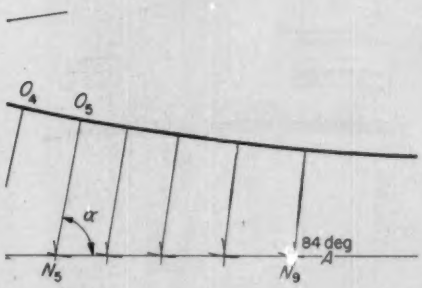


Fig. 5 — Graphical construction of cam profile which corresponds to derived cam cycloid for constant moment.

Operating Limits

Examination of a cam constructed by this graphical procedure shows that the usable portion of the cam profile is confined to that part of cycloid Y_C between $\alpha_{max} = 84$ deg, and $\alpha_{min} = 30$ deg. On the cam itself, these limits encompass a polar angle of 290 deg, corresponding to a cam rotation of 290 − (84 − 30) = 236 deg.

An empirical equation fitted to the cam contour can be expressed as two logarithmic spirals strung together. These equations are expressed in terms of size parameter, c, since all cam profiles are geometrically similar. For $0 \leqq \theta \leqq 180$ deg,

$$r = \frac{c}{4}\left(e^{0.550\theta - 1.640} + 1.116\right) \qquad (5)$$

and for 180 deg $\leqq \theta \leqq$ 290 deg,

$$r = \frac{c}{4}\left(e^{0.0133\cosh\theta + 1.280} - 2.000\right) \qquad (6)$$

where θ = polar angle, rad; c = size parameter, in.; and r = polar radius to the center line of the flexible band, in.

When this method is applied to the solution of a problem, operating displacement of the external system and, also, the desired constant force or torque are known. First step is to convert total displacement into a cam rotation which does not exceed maximum permissible movement of 236 deg. This conversion fixes the value of constant torque M, which acts about the cam center, and provides a reasonable idea of loads acting on the spring-cam system.

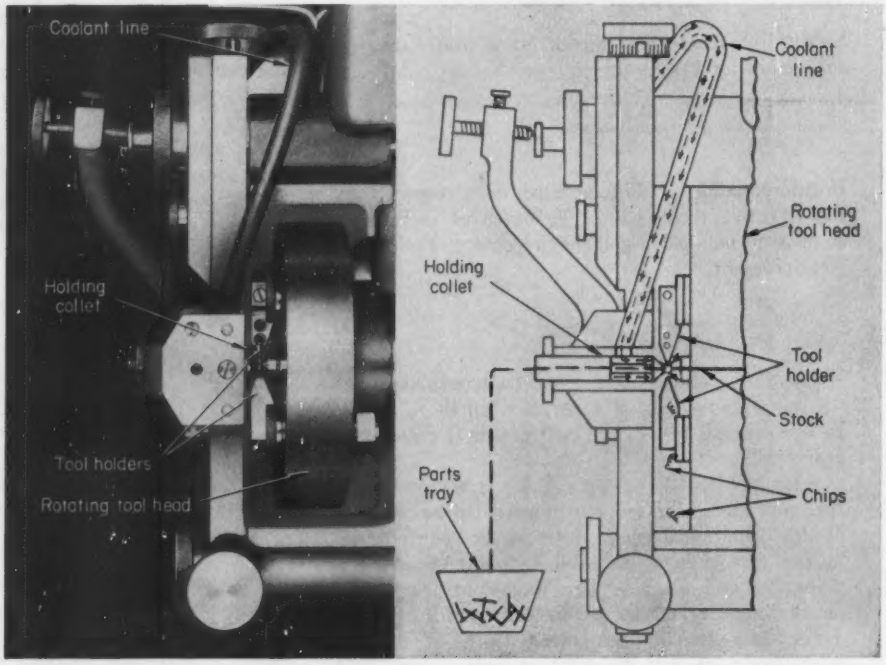
Next, a minimum value of h can be established on the basis of such considerations as shaft diameter, size of cam hub, and type of flexible band. From this value of h, size parameter, c, is calculated using Equation 2. For a given value of h_{min}, $l_{max} = h_{min} \tan \alpha_{max}$. Therefore, $c = (h^2_{min} \tan 84 \text{ deg})^{1/2} = 3.08\ h_{min}$. After size parameter c is determined, cam dimensions are calculated from Equations 5 and 6. Distance a (Fig. 2) is equal to 6.00 c. As the final step, spring gradient k is determined from Equation 2. Thus, a spring designed to suit requirements of free length, gradient, total deflection, and maximum load is obtained.

Since torque M acting on the cam shaft is constant, the cam can be held in any position and the spring merely taken up until the required torque value is attained. Once set, the system requires no further adjustment. As long as the spring-cam unit remains within the prescribed operating range, it will continue to perform as specified.

References

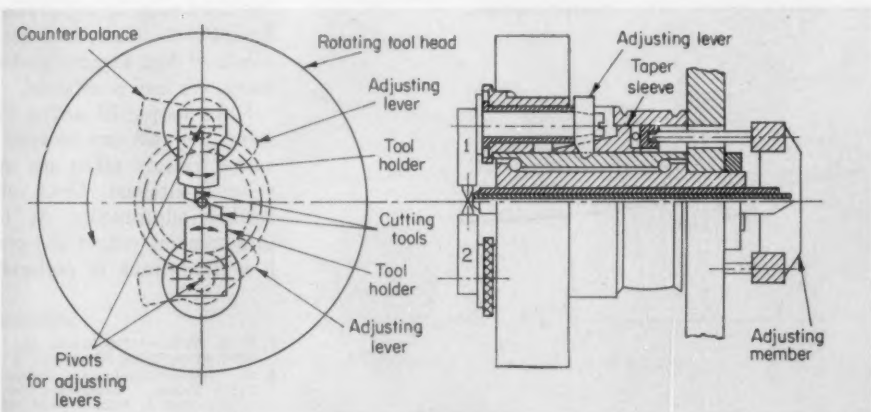
1. F. A. Votta—"The Theory and Design of Long-deflection, Constant-force Spring Elements," *Transactions ASME*, Vol. 74, 1952.
2. K. Hain—"Gelenkarme Bandgetriebe fur den Kraftausgleich durch Federn," Grundlagen der Landtechnik, Dusseldorf (Germany), Heft 4, 1953. ("Band Mechanisms of Limited Link Number for Force Balance by Means of Springs")

Tapered Sleeve Adjusts Both Tools

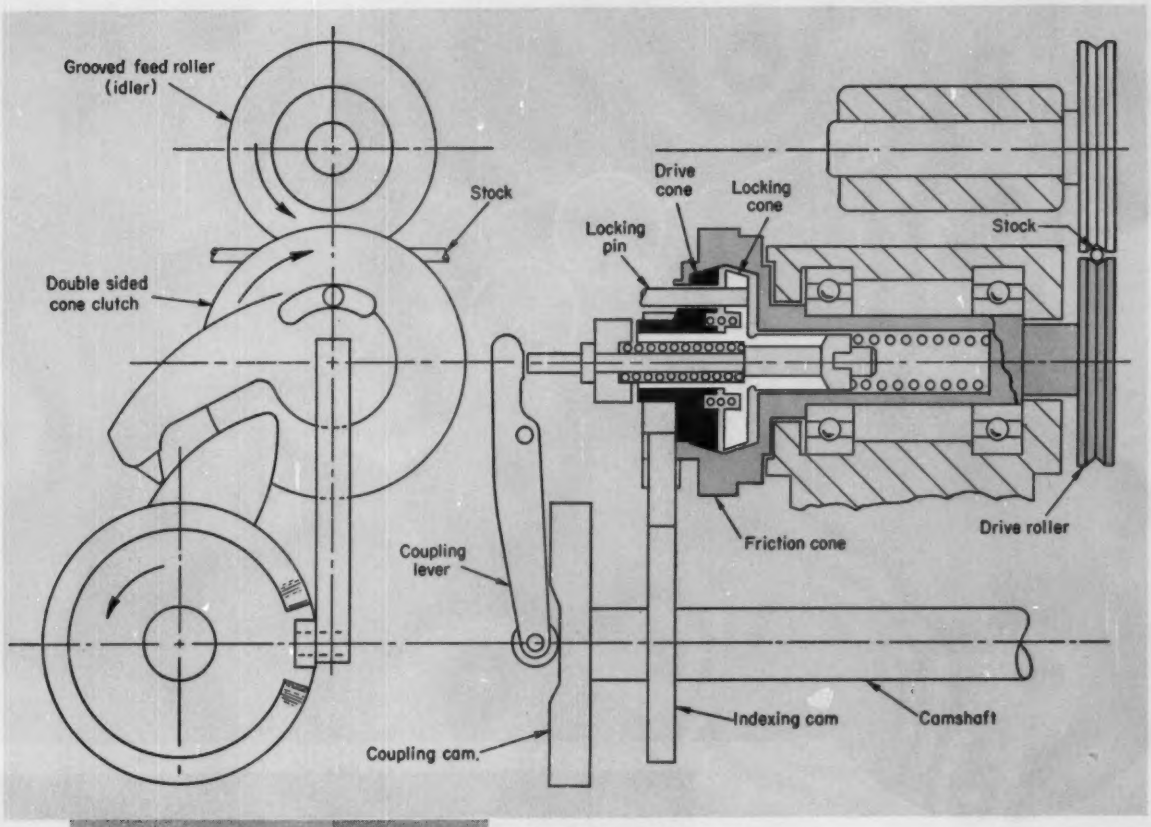


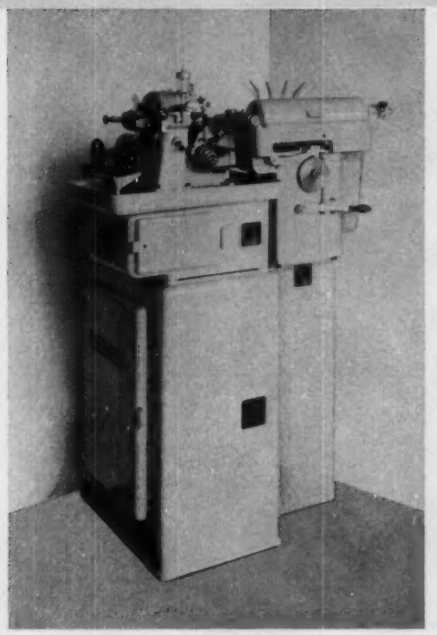
ROUGHING AND FINISHING TOOLS move in and out alternately in response to the controlling motion of a single tapered sleeve in this miniature Swiss lathe. Wire from a coil can be fed to the machine because tools revolve around the stationary stock.

ADJUSTABLE TOOL HOLDERS support two cutting tools made of solid cemented carbide. Each tool holder is positioned by an adjusting lever which engages an axially movable taper sleeve. The adjusting levers are not symmetrical but mounted on a common side. As the taper sleeve is axially displaced, one cutting tool moves in while the other moves out. Taper sleeve furnishes pressure for positive engagement of tool 1, which is usually used for roughing cuts. For finish cuts the taper sleeve is moved axially, disengaging tool 1, and allowing tool 2 to move in. Centrifugal force on a counterweight maintains engagement of tool 2 for light, finish cuts.



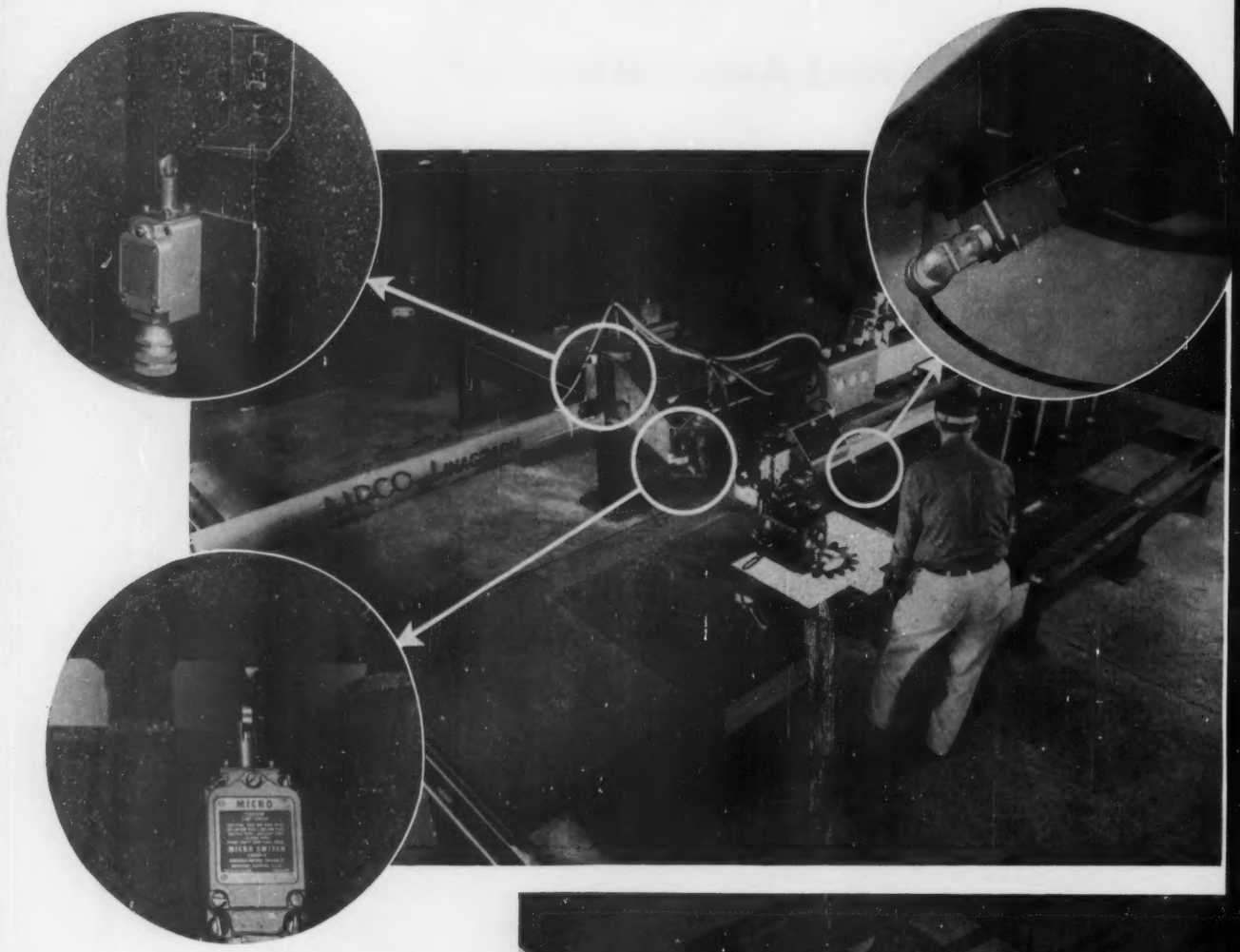
On Wire-Turning Automatic



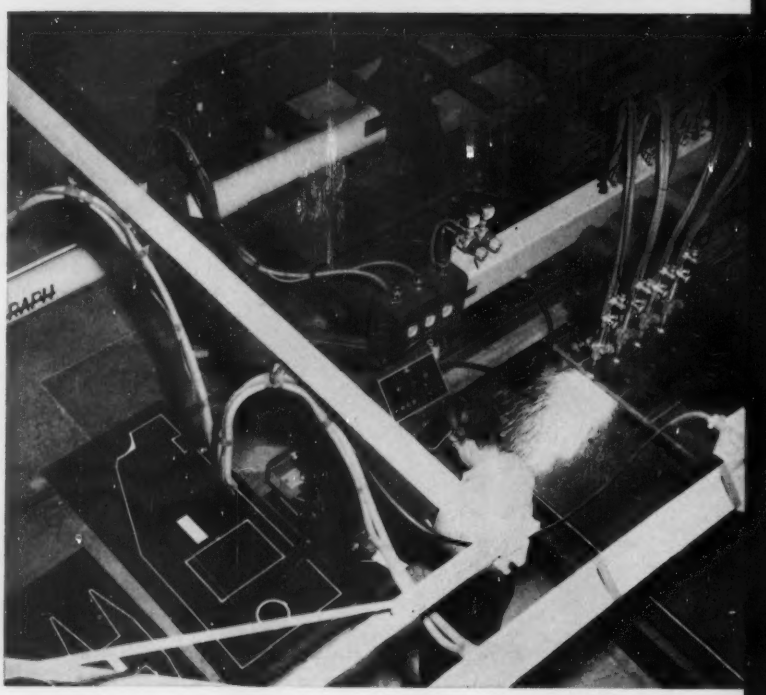


STOCK-FEED MECHANISM USES grooved feed rollers. The drive roller is mounted on a spindle with a double-sided cone clutch. During feed periods, a drive cone engages the hollow friction cone to drive the roller. Axial position of drive cone and locking cone is controlled by a coupling cam and a coupling lever. The locking cone, disengaged from the hollow, driven cone during feed periods, is nonrotatable because locking pin extends through a slot in the feed cone and connects with lathe frame.

Standard version of coil-fed automatic accommodates stock up to ⅛ in. diam. Max length of workpieces is 1 in., and output up to 100 pieces per min. A special attachment straightens stock taken directly from a coil. The automatic lathe is a design of Esco SA, Les Geneveys-sur-Coffrane, Switzerland.

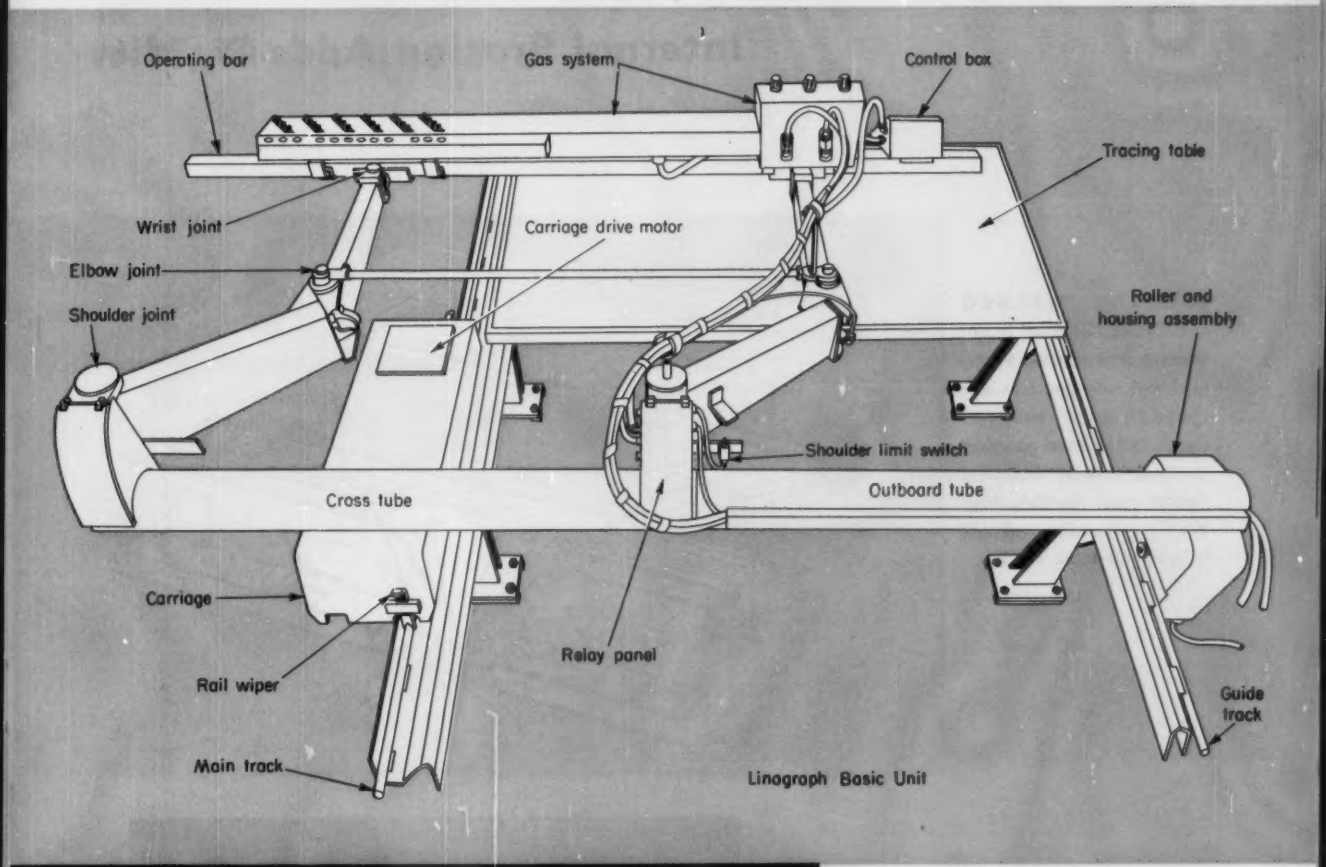


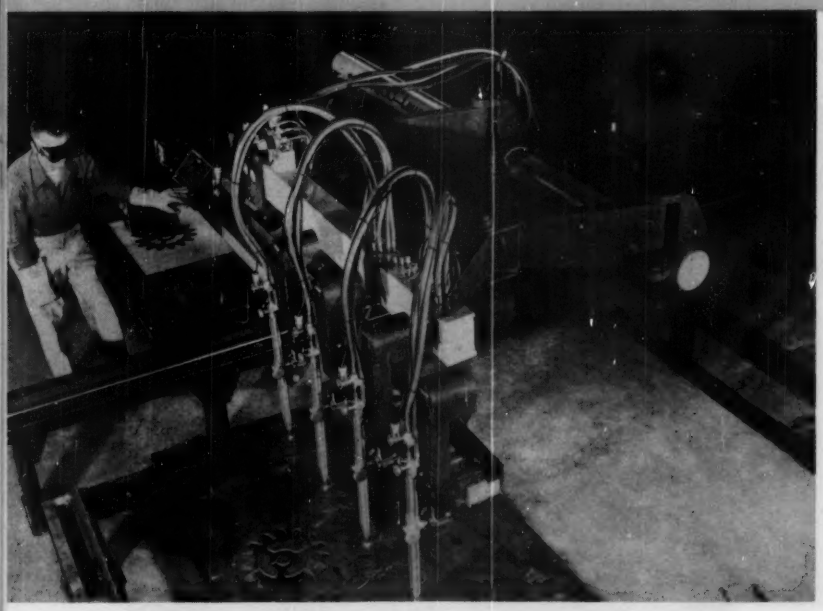
SHOULDER, ELBOW, AND WRIST joints of a pantographic torch cutter have "nerve endings" in the form of limit switches that go into action when the joints reach their limit of motion.



PATTERN SENSOR feeds steering signals to a friction drive wheel powered by a constant speed electric motor. Torch cutting accuracy of ±1/64 in. is maintained because the drive wheel moves only the light, well-balanced arms of the pantograph. Airco Linagraph is a development of Air Reduction Co., New York City.

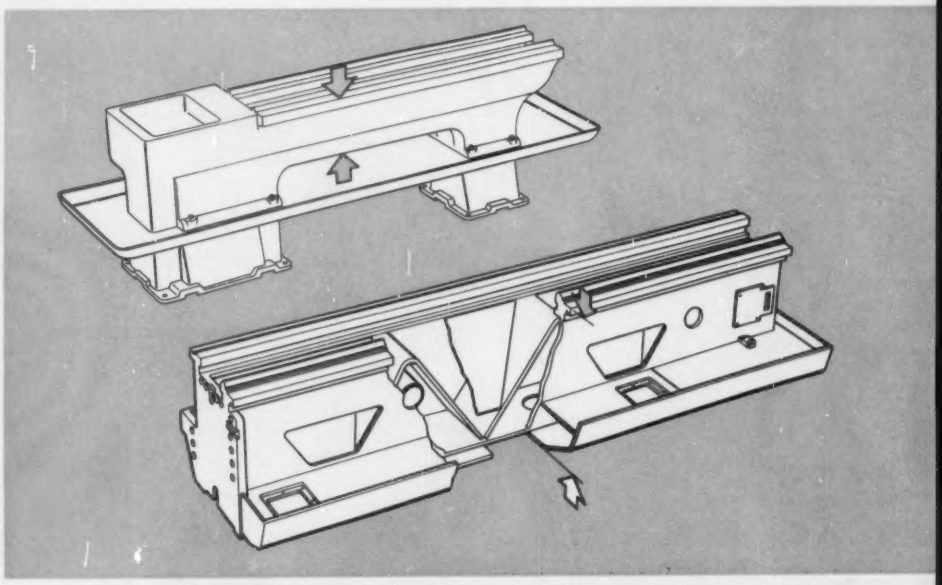
Nervous System for a Pantograph



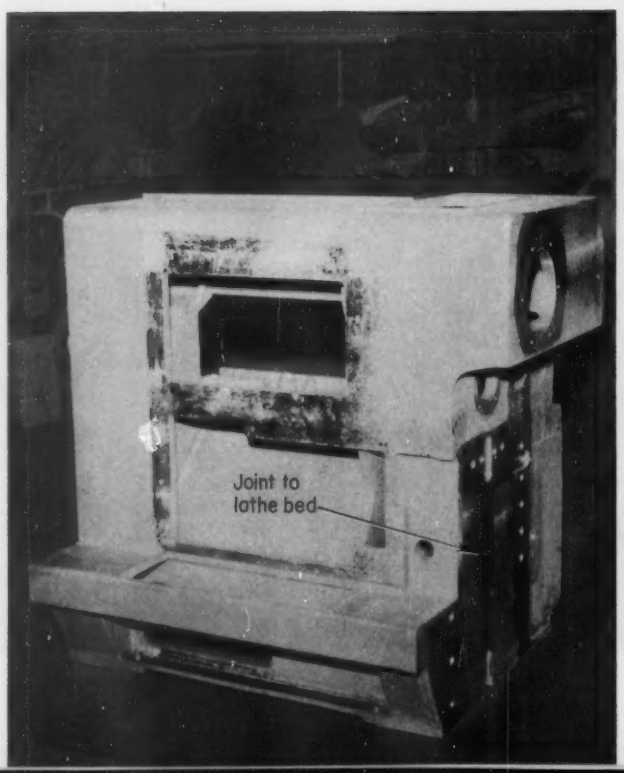


LIMIT SWITCHES actuate the carriage drive motor that moves the carriage along tracks to a more neutral position with respect to working locale. Unique pantograph uses two four-bar linkages sharing a common link (tie rod at elbow joints), to achieve full-scale reproduction of tracing motion anywhere along tracing bar. This allows four motorized torches (or six manual) to be mounted on the bar to cut identical full-scale parts.

Internal Bracing Adds Rigidity

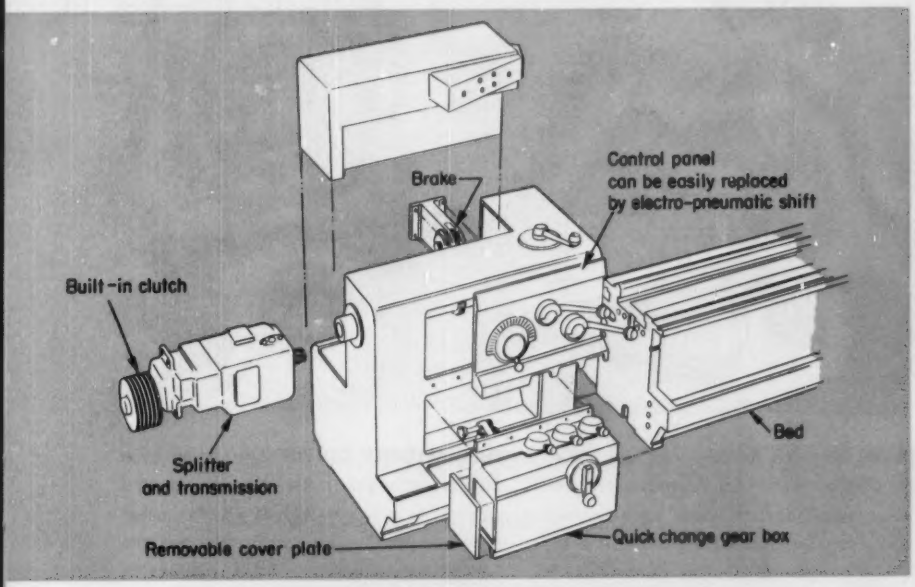


INTEGRATED WELDED STRUCTURE, bottom, incorporates chip pan, oil sump, pedestal, and bed into one closed box-like structure. Depth of closed portion (arrows) is twice that of a typical cast model, top. Welding permits internal bracing for more rigidity.



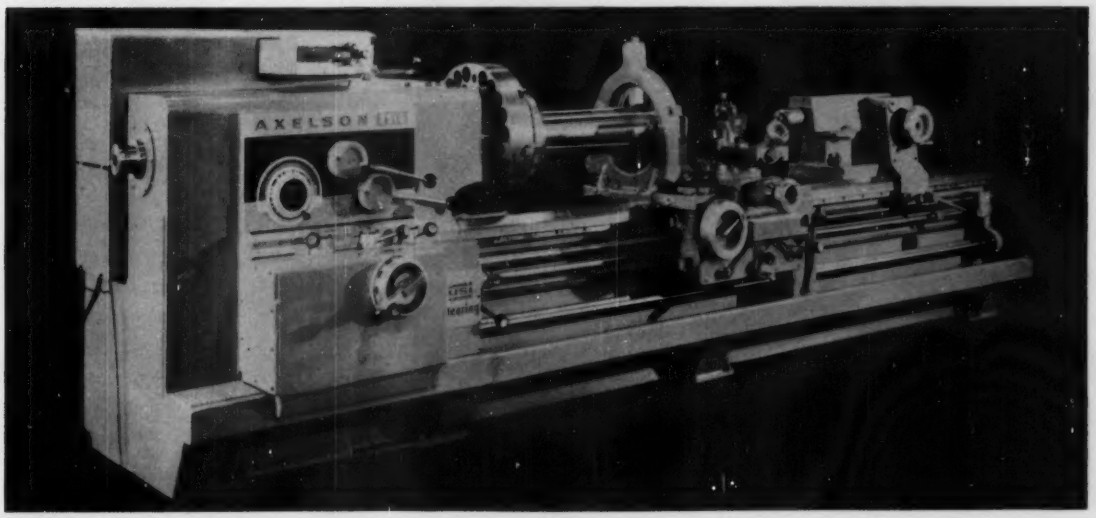
HEADSTOCK WELDMENT is built to contain all drive elements. Tricky oil seals are eliminated, and a single wide-flange joint makes an unusually rigid joint to the lathe bed.

to Welded Lathe Bed

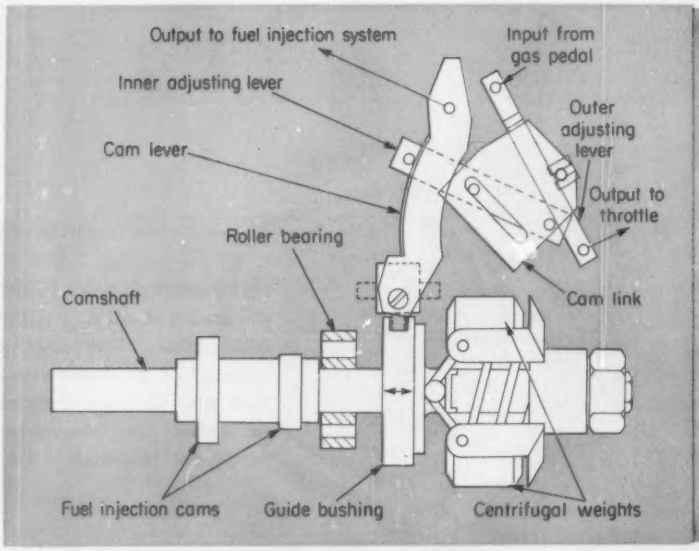


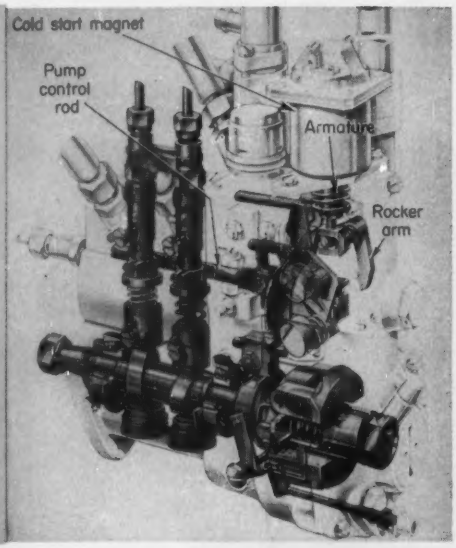
FREE-STANDING HEAD STOCK is fastened to the end of the bed rather than being mounted on it. Spindle and feed drive units are attached to, rather than assembled within, the headstock.

Welded lathe bed designed under the direction of John K. Liu, associate director of research and development, Clearing Division, United States Industries Inc., Chicago, was a winner in the Machine Design Award Program sponsored by the James F. Lincoln Arc Welding Foundation, Cleveland.



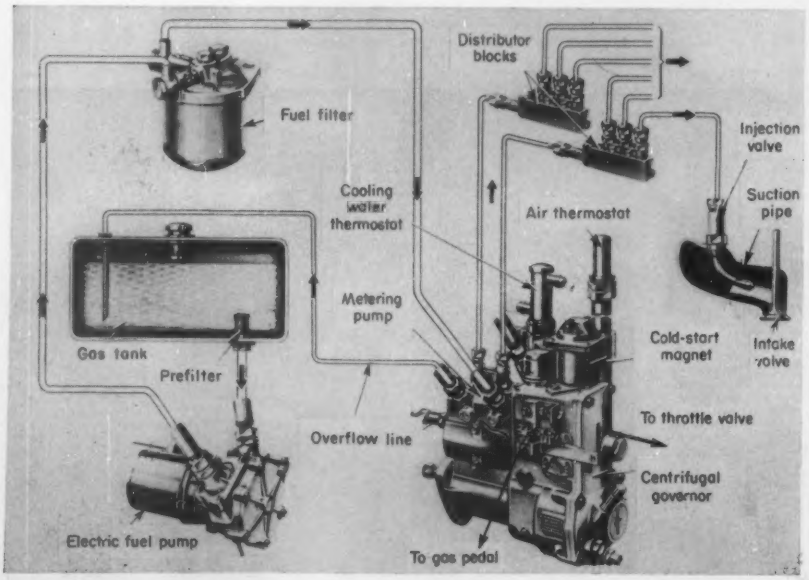
Mechanical Integrator Solves Simultaneous Equations For New Fuel-Injection System





COMPLETELY MECHANICAL LINKAGE between throttle and fuel metering in a new fuel-injection system uses a mechanical integrator. Motion of gas pedal presents the integrator with a specific linear equation (slot in cam link). Speed of motor offers a curve (back of cam lever). The inner adjusting lever relates the two equations. Output of the mechanism controls throttle and fuel-metering elements in a system developed for Daimler-Benz AG by Robert Bosch GmbH, Stuttgart, Germany.

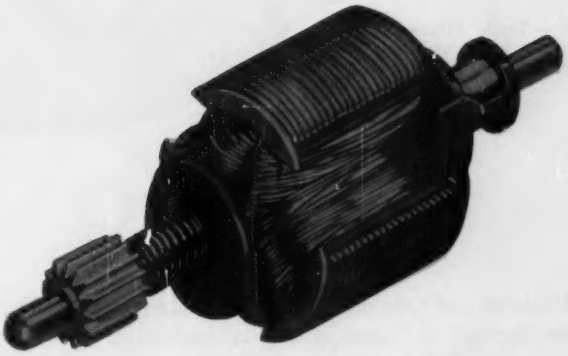
FUEL-METERING OUTPUT is modified by a magnet-actuated rocker arm during cold starts. As armature moves up, the rocker arm's control surface moves toward the end of the pump-control rod, limiting its motion to the right. The integrator output resumes control only if its demands exceed those of the cold-start magnet (motion to the left). Pump-control rod transfers information from integrator to pumps by rack-and-gear system.

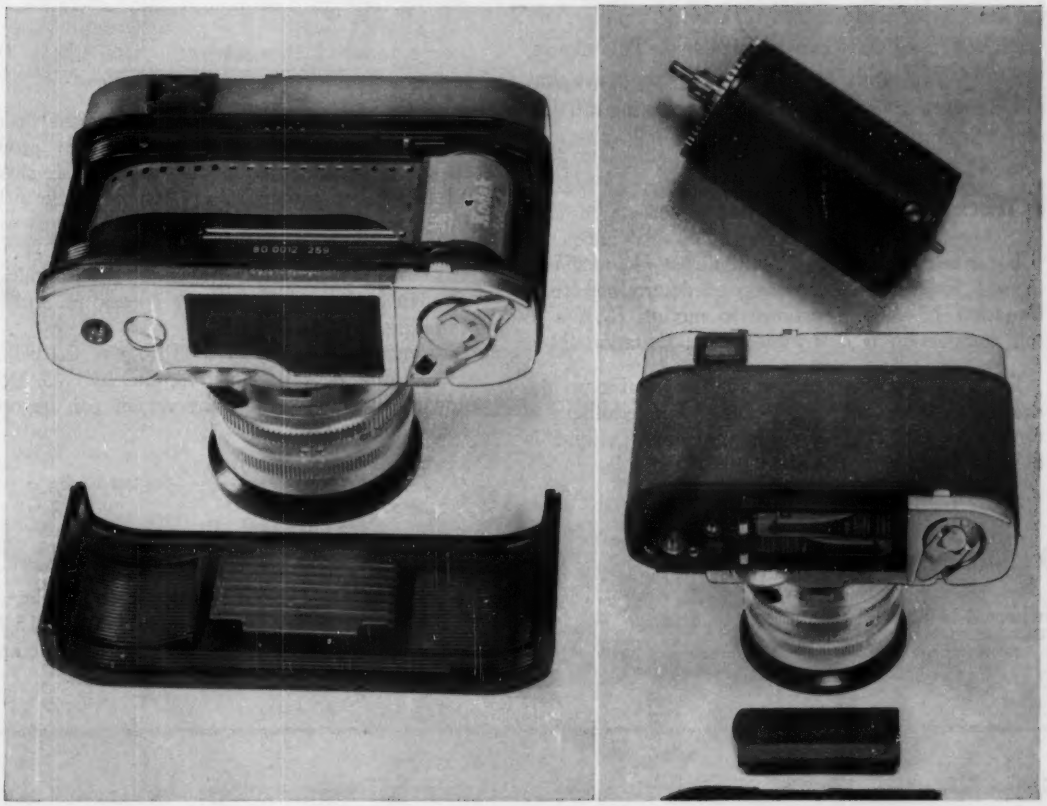


MAGNET IS CONTROLLED by thermostats measuring temperature of intake air and cooling-system water. Carburetion occurs in an intake suction pipe before fuel and air enter the cylinder.

Motor Takes Winding Chore Out of Picture Taking

TINY BATTERY-RUN MOTOR is hidden in the take-up spool of an automatic 35-mm electric camera. Snap the shutter and the motor-housing spool revolves around the armature to wind off one frame of film and cock the shutter for the next shot. Power comes from small dry cells in the base of the camera. Graphic 35 Electric is a product of Graflex Inc., Rochester, N. Y.





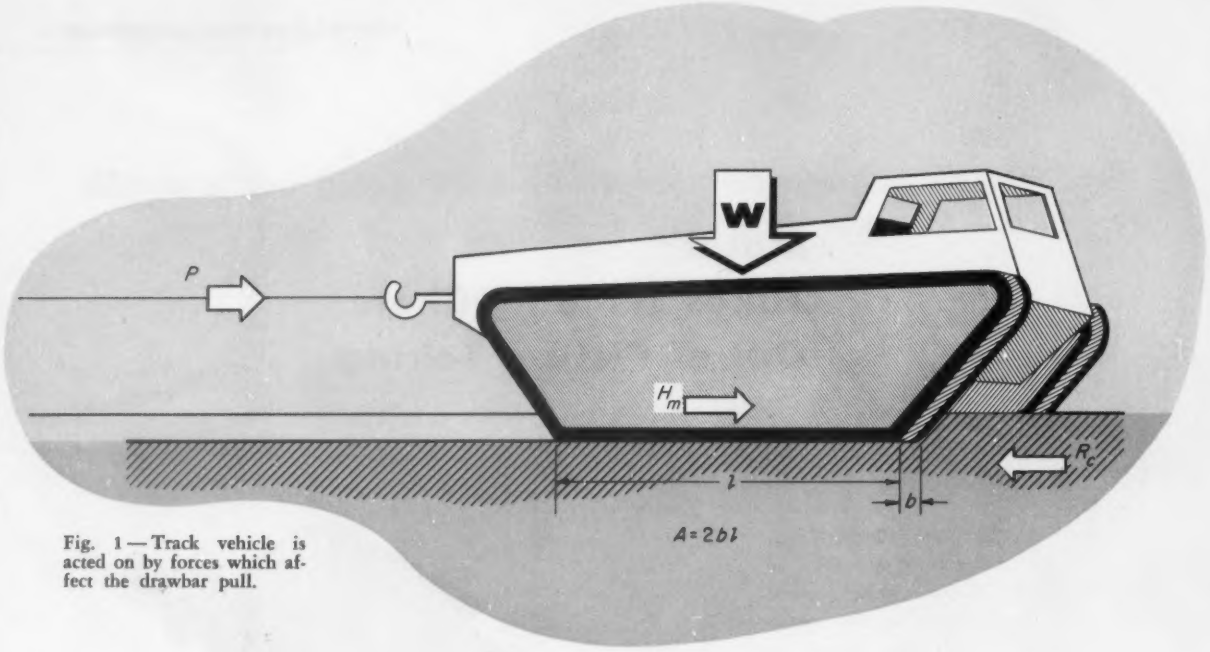


Fig. 1 — Track vehicle is acted on by forces which affect the drawbar pull.

SOIL thrust and resistance to vehicle motion may be expressed in terms of certain mechanical properties of the ground, and in terms of vehicle loads and dimensions. Once these properties are correlated, performance of a vehicle under any given soil conditions can be predicted. This article, the third in a series, presents some of the ways that soil characteristics can be used in predicting off-the-road vehicle performance.

Tracks and High Deflation Tires

For track vehicles, maximum thrust H_m available in soil for vehicle propulsion is determined from Equation 1.[1] Also, resistance to motion R_c due to soil compaction is determined from Equation 22.[2]

Drawbar Thrust: The net thrust available on the drawbar for pulling, accelerating, and climbing is obtained from the force diagram, Fig. 1, and is defined as the difference between H_m and R_c:

$$P = Ac + W \tan \phi - \frac{2}{(n+1)(k_c + bk_\phi)^{1/n}} \left(\frac{W}{2l} \right)^{(n+1)/n} \quad (23)$$

where A is the total ground contact area.

[1]References are tabulated at end of article.

The approximate slope that a vehicle can climb in a given soil is:

$$s = \frac{P}{W} = \frac{Ac}{W} + \tan \phi - \frac{2W^{1/n}}{(n+1)(k_c + bk_\phi)^{1/n}(2l)^{(n+1)/n}} \quad (24)$$

The ratio P/W has often been called the "coefficient of adhesion." Equations 23 and 24 produce reasonably accurate predictions for moderate sinkage and slopes. For higher sinkage and nonuniform load distributions, Equations 23 and 24 become more complex in structure.[3]

EXAMPLE 1: The dimensions of the ground contact area for a track vehicle are $l = 50$ in. and $b = 10$ in., Fig. 1.

Assume weight $W = 15{,}000$ lb, $c = 0.3$ psi, and $\phi = 20$ deg, $n = 0.5$, $k_c = 8$, and $k_\phi = 3$. Determine the maximum slope the vehicle can negotiate. From Equation 24,

$$s = 100 \left[\frac{2(50)(10)(0.3)}{15000} + \tan 20 \text{ deg} - \frac{2(15000)^2}{1.5(8+30)^2(100)^3} \right] = 17.7 \text{ per cent}$$

Since Equation 24 was derived by dividing Equation 23 by W, the drawbar pull is $P = 0.177$ (15,000) = 2655 lb. Performance of low-pressure pneumatic

Track and Wheel Evaluation

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U. S. Army Ordnance
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tires can be estimated in the same manner if the tires deflect to form an elongated, flat area.

EXAMPLE 2: Determine the drawbar pull for the vehicle in Example 1 if it is built with eight tires which produce four, rectangular, ground contact areas with dimensions $b = 8$ in. and $l = 12$ in., Fig. 2. If the load distribution is constant across all wheels, the pull from Equation 23 is

$$P = 8(8)(12)(0.3) + 15000 \tan 20 \text{ deg} - \frac{8}{(1 + 0.5)[8 + 3(8)]^2}\left(\frac{1875}{12}\right)^3 = -13370 \text{ lb}$$

The negative sign in the answer indicates that the motion resistance exceeds the soil thrust for this vehicle, and the vehicle will not move. However, if the soil were dry, so that $n = 1$.

$$P = 5630 - \frac{8(156)^2}{1.5(32)} = 1600 \text{ lb}$$

Hence, the vehicle would move and could negotiate slopes of 10 per cent, $s \cong 100$ (1600/15000).

Compaction: It was assumed in these examples that each wheel moved over previously uncompacted soil. Practically, this may not be true for soils with $n = 0.5$. The motion resistance of the first wheel would be less than that of the last one, since the soil would tend to weaken under each wheel pass.

For soils with $n = 1$, strength is not usually affected by repetitive loading and the last wheel would have the same motion resistance as the first.

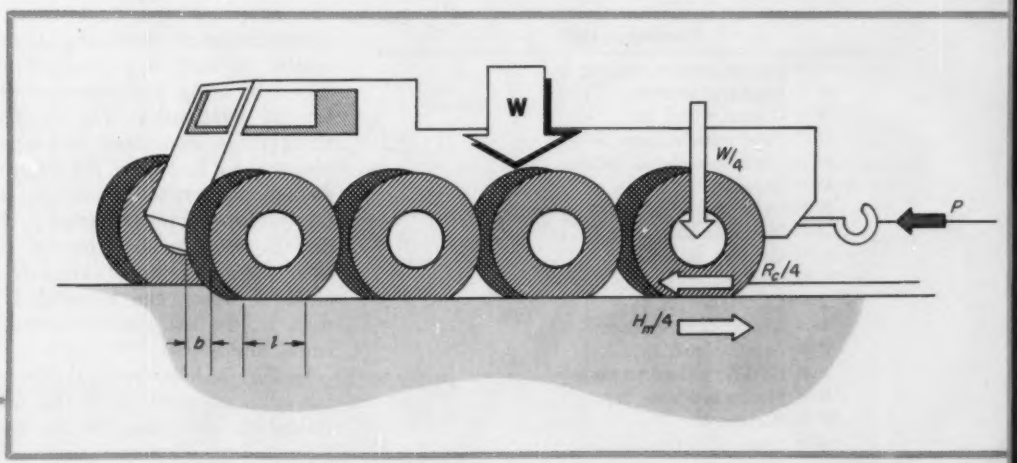


Fig. 2 — Wheels of vehicle distribute load to soil at distinctive points.

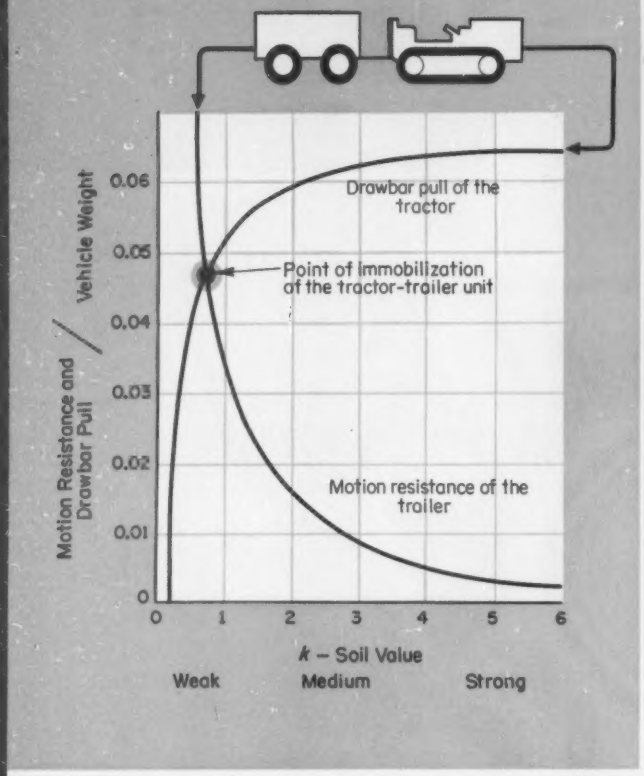


Fig. 3—Intersection of drawbar pull and motion resistance curves is point of vehicle immobility.

To evaluate performance more accurately, sets of values for k_c, k_ϕ, and n should be measured after consecutive-soil remoldings by the wheels, and each wheel should be evaluated separately.

Excessive Sinkage: Changes in weather bring changes in soil characteristics. Since vehicle design cannot be changed to match these changing soil conditions, the state of the soil that will limit operation of the vehicle must be determined.

Nomenclature

A = Ground contact area, sq in.
a = Empirical constant
b = Contact width, in.
C = Total cohesive force, lb
c = Coefficient of soil cohesion, psi
D = Diameter, in.
f_t = Unit motion resistance, sq in. per lb
H_m = Maximum soil thrust, lb
k_c = Cohesive modulus
k_ϕ = Frictional modulus
l = Contact length, in.
n = Soil property exponent
P = Drawbar pull, lb
p = Uniform ground pressure, psi
R = Motion resistance, lb
W = Weight, lb
ϕ = Angle of friction, deg

Wheel Vehicles

Fig. 3 shows a track vehicle towing a wheel vehicle through a soil for which soil parameters k_c and k_ϕ are denoted by $k = (k_c/b) + k_\phi$. The trailer is equipped with high-pressure pneumatic tires which, in a soft ground, behave like rigid wheels. The motion resistance of a rigid wheel is[3]

$$R_c = \frac{1}{(3-n)^{(2n+2)/(2n+1)}\ (n+1)\ (k_c + bk_\phi)^{1/(2n+1)}} \times \left(\frac{3W}{D^{1/2}}\right)^{(2n+2)/(2n+1)} \quad (25)$$

Sinkage for this type wheel is

$$z = \left[\frac{3W}{(k_c + bk_\phi)(3-n)D^{1/2}}\right]^{2/(2n+1)} \quad (26)$$

Hence, the curve for drawbar pull of the tractor can be determined by substituting increasing values of k into Equation 23. Similarly, the motion resistance curve for the trailer is plotted by using Equation 25. These curves show a hyperbolic characteristic, Fig. 3. The intersection of the curves denotes the "weakest" state of soil—the limit of operation.

Sometimes the "weakest" soil condition exists when the trailer and/or the tractor "bottom." This point is determined by calculating sinkage from Equation 26 for the rigid wheel trailer, and for the tractor from Equations 17 or 18.[2] If, for a specific soil condition, the sinkage is larger than the ground clearance of the tractor or trailer, the condition is a critical one.

Although accuracy of prediction in the field may be of statistical character only, it may be quite accurate in the laboratory. Fig. 4 and 5 show comparison of values predicted by equations for wheels, and those measured by equipment, Fig. 6. Similar agreement has been noted during track investigations.

Tire Deflection: One of the important factors in analyzing a pneumatic tire is determining when the tire behaves like a rigid wheel, and when it becomes flattened, producing a ground contact area similar to that of a track. This problem can be solved by using a physico-geometrical model of the tire-soil relationship, Fig. 7. The tire is flattened along the l_1 dimension and remains approximately round along l_2. Hence, the ground pressure is strong enough to exercise pressure p_g, which equals inflation pressure p_i plus pressure p_c. Stiffness of tire carcass p_c depends on structural characteristics, such as number of plies, thickness of the wall, direction of fabric fibers, and material. If $p_i + p_c$ is larger than p_g, the tire remains round, similar to a rigid wheel, and $l_1 = 0$.

In Fig. 7, R is the total motion resistance caused by soil compaction and the force, Wf_t, which is wasted on deflecting the tire carcass. Soil pressure P_s acting on the curved portion of the tire is evalu-

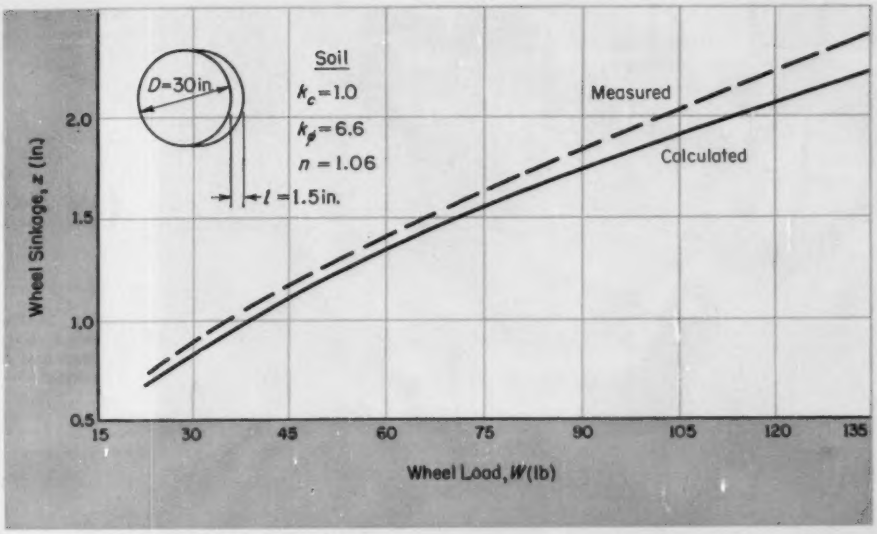


Fig. 4 — Vehicle sinkage is directly related to wheel load.

ated as a function of sinkage.[3,4]

Towing resistance of a low-pressure pneumatic tire, Fig. 4, is[4]

$$R = \frac{[b(p_i + p_c)]^{(n+1)/n}}{(k_c + bk_\phi)^{1/n}\,(n+1)} + \frac{Wu}{p_i{}^a} \qquad (27)$$

where u and a = empirical coefficients depending on tire stiffness. Values of p_c, u, and a must be determined experimentally for each tire if Equation 27 is to be solved. This evaluation may be done by moving the tire, under various loads and inflation pressures, on a hard surface.

Unit Motion Resistance: Unit motion resistance obtained from experiments may be expressed by

$$f_t = \frac{u}{p_i{}^a} \qquad (28)$$

This resistance is caused solely by hysteresis of tire carcass deflection. When plotted in terms of corresponding inflation pressure p_i, unit motion resistance f_t produces a standard curve of tire deflection resistance, Fig. 8. Equation 28 delineates this curve. Fig. 8 shows experimental data determined for a 7.00 × 16 tire with the tread shaved off, u = 0.12 and a = 0.64.

Carcass Stiffness: When the inflation pressure for a given series of loads is changed, the bearing area of the tire print can be measured. When the load is divided by the area of the tire print, the actual ground pressure, $p_g = p_i + p_c$, is determined and may be plotted as a function of p_i, Fig. 9. If there is no stiffness in the carcass, $p_g = p_i$. Since this is rarely the case, all the measured values of p_g are located above the $p_i = p_g$ line. The distance between

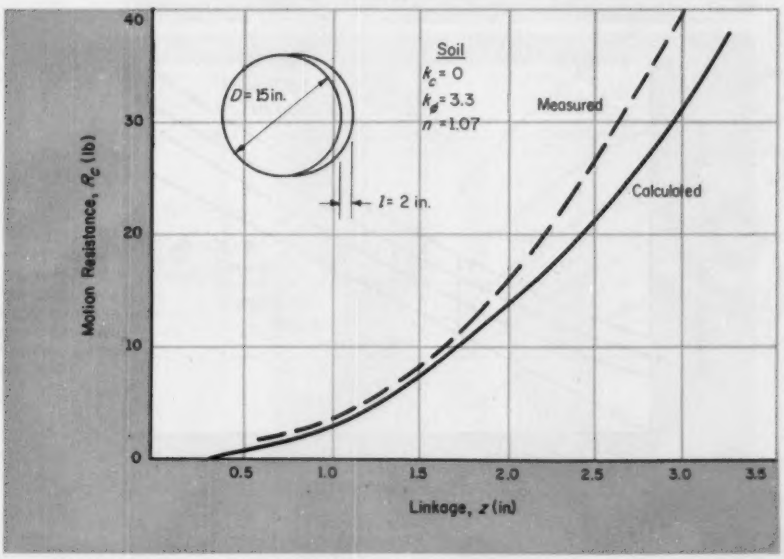


Fig. 5—Variations in soil sinkage affect the motion resistance and hence, performance of the vehicle.

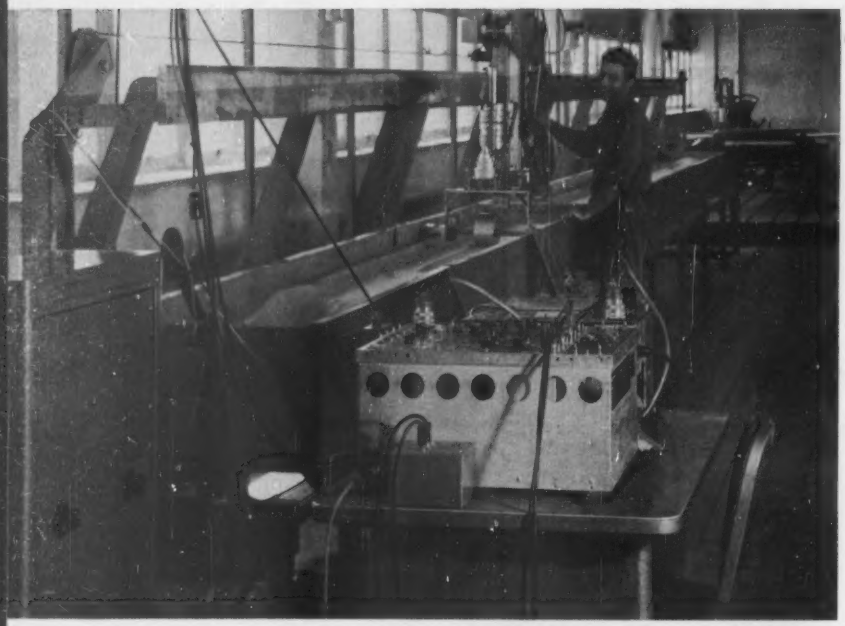


Fig. 6—Overall view of test setup for soil measurement.

Fig. 7—Pneumatic tires deform when moving over soil if the load and inflation pressure are correct.

Photo, courtesy of University of Michigan

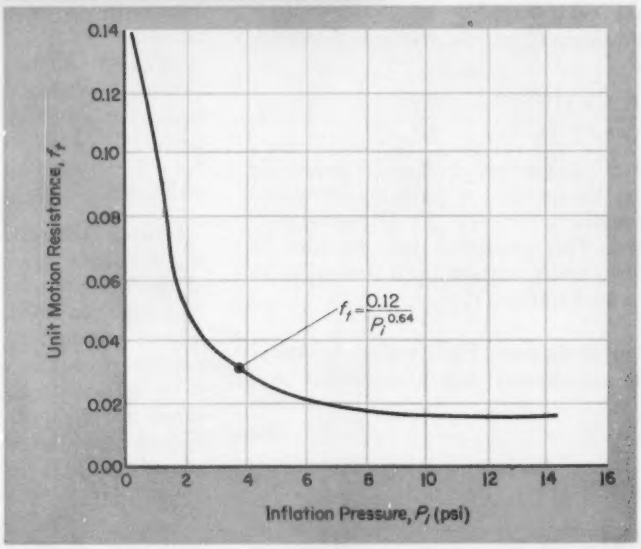


Fig. 8—Unit motion resistance is obtained from standard tire deflection-resistance curve.

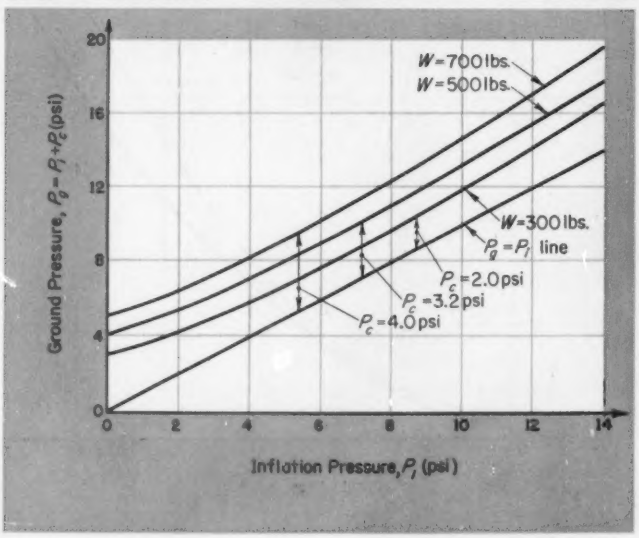
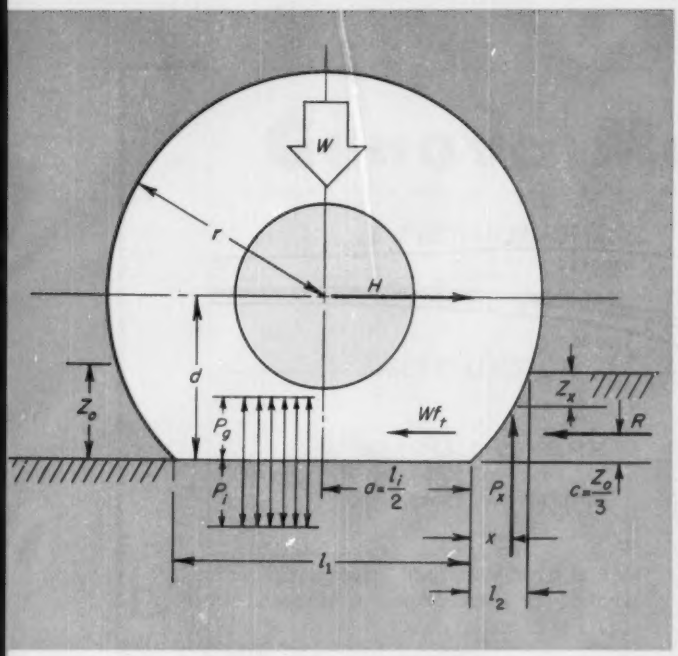


Fig. 9—Carcass stiffness of a tire is determined by the inflation pressure and ground pressure.



$p_i = p_g$ line and the given line for p_g gives the amount of p_c at given load. Lines obtained in this manner are called standard curves of carcass stiffness.

Fig. 9 shows stiffness data measured for a 7.00 × 16 tire. From the figure, p_c is practically constant for a given load. Hence, all the necessary data are available to calculate the towing resistance of the tire from Equation 27.

Critical Pressure: Equations for equilibrium of the forces and moments shown in Fig. 7 indicated that there is a critical inflation pressure $(p_i)_c$, above which the tire behaves as a rigid wheel, and below which it produces a flat, ground contact area. This pressure is

$$(p_i)_c = \left[\frac{W(n+1)}{b\left[\frac{3W}{(3-n)bkD^{1/2}}\right]^{1/(2n+1)}} \right] \times \left\{ D - \left[\frac{3W}{(3-n)bkD^{1/2}} \right]^{2/(2n+1)} \right\}^{-1/2} - p_c \quad \ldots (29)$$

where $k = (k_c/b) + k_\phi$.

EXAMPLE 3: Equation 29 is plotted in terms of varying soil conditions k and n, Fig. 10. The family of curves shown, Fig. 10, are typical for the 7.00 × 16 tire with weight of 500 lb.

Assume that the normal inflation pressure is 24 psi. To increase cross-country performance, the inflation pressure is lowered to 12 psi. If the terrain has values of $n = 0.5$ and k between 2 and 4, determine whether or not a tire with low pressure will perform better in the soil than the high-pressure tire. Fig. 10 indicates that decreasing inflation pressure does not help in this particular soil, since the tire continues to behave as a rigid wheel. Inflation pressure p_i must be lowered below 8 psi in soil conditions defined by $k = 2$, and below 10 psi in soils defined by $k = 4$, to obtain any deflection of the tire. Hence, for the given soil, the low-presure tide will not improve performance. Improvement can be obtained in harder soils by decreasing inflation pressure below 12 psi.

Draw-bar Pull: Once the motion resistance of the tire and the thrust are known, the drawbar pull of a tire can be determined. Care must be taken to

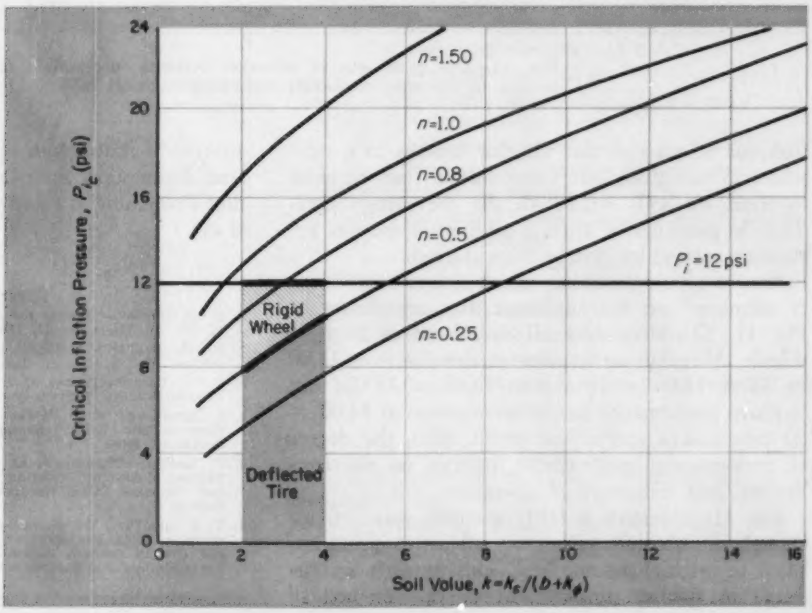


Fig. 10 — When a wheel has an inflation pressure which causes the tire to act as a rigid wheel, a condition of critical inflation pressure is reached.

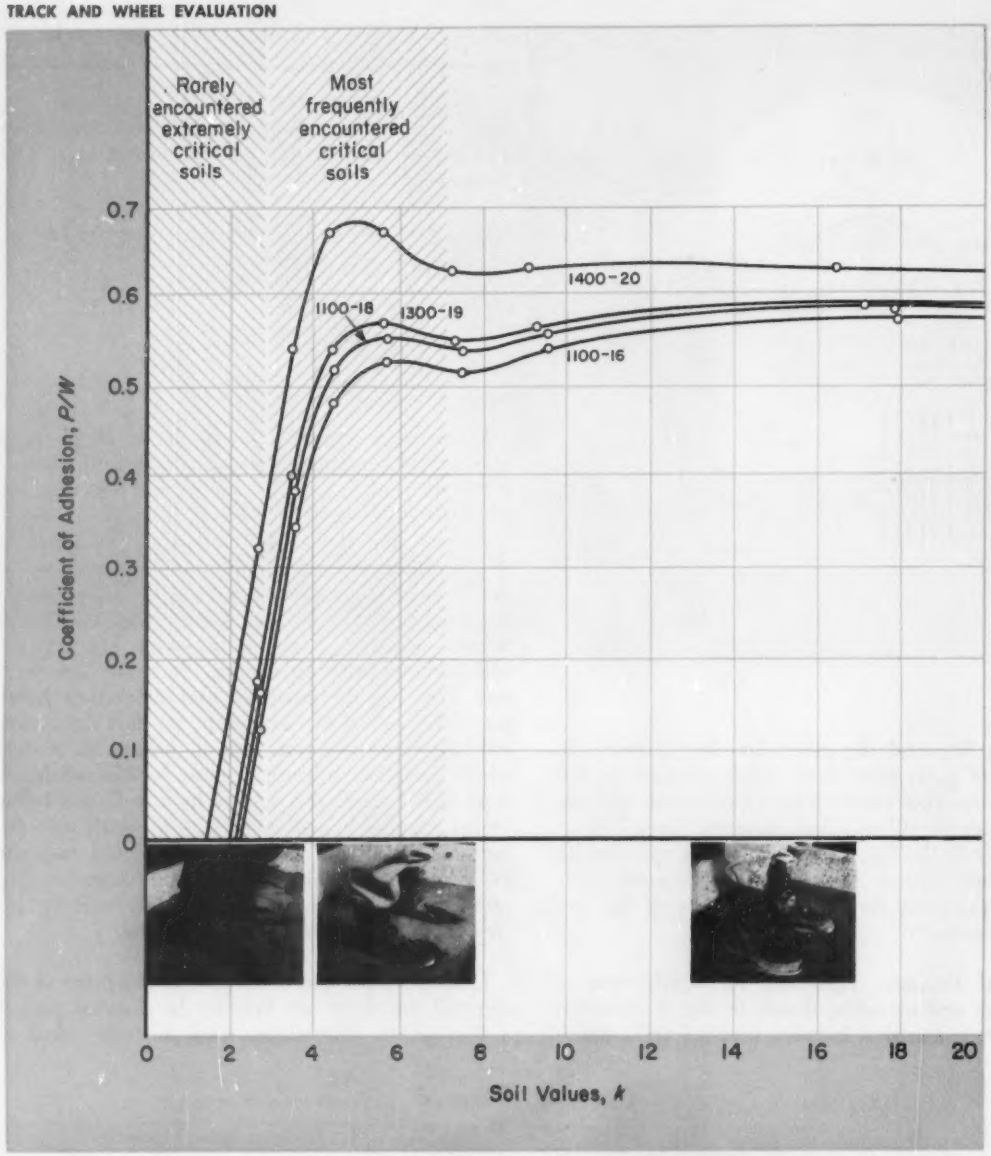


Fig. 11—The coefficient of adhesion becomes increasingly important in the most frequently encountered critical soils.

find out whether or not the tire behaves as a rigid wheel in the given soil. Computations can be quite involved for soils where all the parameters vary. This is particularly true if additional motion resistance, such as bulldozing, is considered.

Results of computations which define "coefficient of adhesion" on four different tires are shown in Fig. 11. The tires were all considered to be rigid wheels. Although an increase in tire size from 11.00 × 16 to 11.00 × 18 and to 13.00 × 19 did not improve performance much, an increase to 14.00 × 20 produced a spectacular result. Also, the degree of performance improvement depends on soil conditions, and frequency of operation.

Fig. 11 represents a fairly accurate solution, although the absolute values are subject to errors implicit in original assumptions. This presents a challenge to further development of this method of analysis.[5,6] The graph of Fig. 11 emphasizes that in land locomotion there are no absolute values and that everything is relative to the type and the state of soil.

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Geneva Mechanisms

. . . . *a recommended "standard" series of three to nine-point drives and their design details*

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EQUATIONS, graphs, and procedures in this article comprise a simple means of selecting the characteristics of Geneva mechanisms suitable to desired cycles and loadings.

Characteristics of Types: A Geneva consists of two basic elements. The continuously revolving arm with its roller, and the intermittently revolving slotted wheel. The wheel may have three or more points or slots. In this article, the greatest number included is nine.

The three-point type indexes in the smallest fraction of cycle time. It gives rather abrupt action, and the wheel shaft must be overhung because the swing of the arm precludes a through-wheel shaft.

Types having six points and more give very smooth action. Indexing becomes a larger fraction of cycle time as the number of points increases. The nine-point type appears to be the largest that will permit a through-arm shaft adequate for heavy service. This characteristic is due to the sweep of the wheel.

A special arrangement may be made wherein the

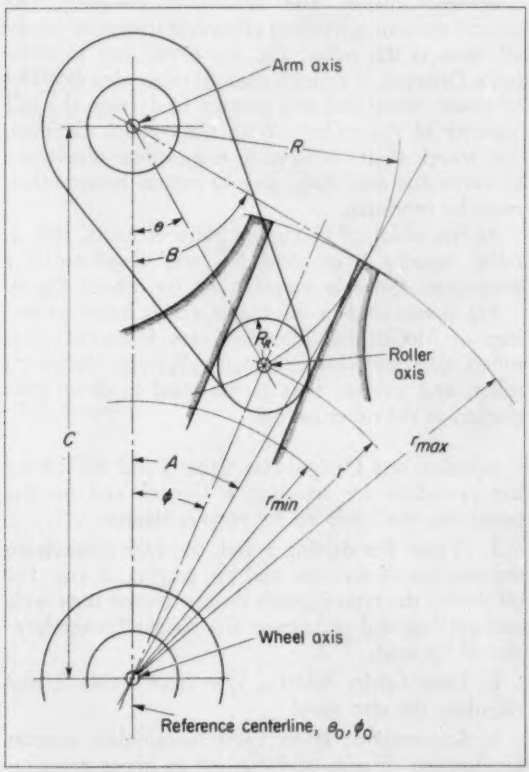

Fig. 1—Physical features of arm and wheel.

Nomenclature

A = Half of angle between consecutive slots in wheel, deg
B = Half of indexing angle of arm, $90 - A$, deg
$2B/360$ = Ratio of indexing to cycle time
C = Center distance, arm axis to wheel axis, R/k, ft
f = Force on roller, lb
f_a = Allowable torque on wheel, lb-ft
I = Moment of inertia of load, lb (mass)-ft²
J = Moment of inertia of load, lb-ft²
k = Center distance ratio = R/C = sin A
l = Compound term = $1 + k^2 - 2k \cos \theta$
N = Arm speed, rpm
N_a = Allowable arm speed, rpm
N_R = Speed of roller, about its own axis, rpm
n = Number of slots in wheel
R = Arm radius, arm axis to roller axis = Ck, ft
R_R = Roller radius, ft
r = Wheel radius, wheel axis to roller axis, ft
T = Torque on arm, lb-ft
t = Torque on wheel, lb-ft
t_a = Allowable torque on wheel, lb-ft
α = Wheel acceleration, rad per sec²
θ = Arm displacement from arm-wheel centerline, deg
ϕ = Wheel displacement, deg
ω = Wheel velocity, rad per sec
Ω = Arm velocity, rad per sec
Ω_R = Roller velocity, about its own axis, rad per sec

Subscripts:
Numeral 1 identifies values of characteristics when $\theta = 1$.
For f, T, and t:
Letter I identifies properties due to inertia.
Letter F identifies properties due to friction.

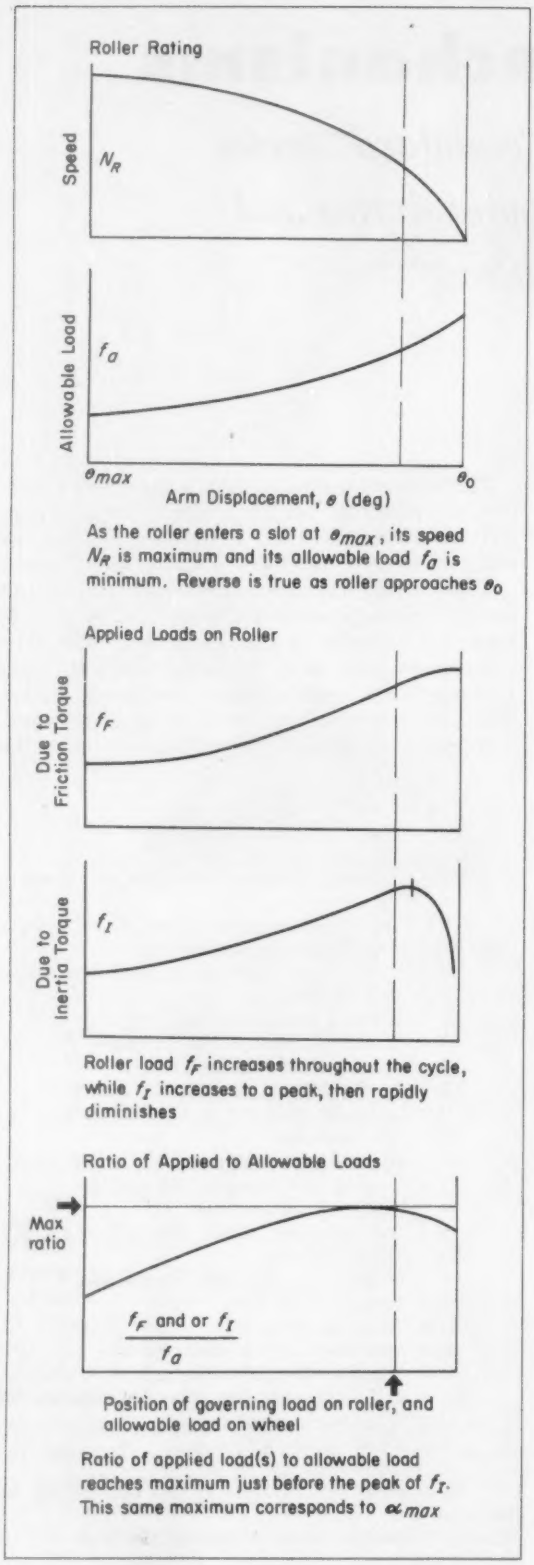
Roller Rating
Speed
N_R
Allowable Load
f_a
θ_{max}
θ_0
Arm Displacement, θ (deg)
As the roller enters a slot at θ_{max}, its speed N_R is maximum and its allowable load f_a is minimum. Reverse is true as roller approaches θ_0
Applied Loads on Roller
Due to Friction Torque
f_F
Due to Inertia Torque
f_I
Roller load f_F increases throughout the cycle, while f_I increases to a peak, then rapidly diminishes
Ratio of Applied to Allowable Loads
Max ratio
$\frac{f_F \text{ and or } f_I}{f_a}$
Position of governing load on roller, and allowable load on wheel
Ratio of applied load(s) to allowable load reaches maximum just before the peak of f_I. This same maximum corresponds to α_{max}

Fig. 2—Location of governing load on roller, and allowable torque on wheel.

roller retracts into the arm which then rotates without indexing. Retraction on call permits stopping the indexing of the work without stopping the drive.

Although the segmental portion of the arm holds the wheel while the wheel is at rest, a bolt-type lock should be provided for the wheel when accurate positioning is required.

Equations for kinematic and kinetic characteristics are listed in:

Table 1—Equations for Geneva Motions

Table 2—Characteristics of Geneva Motions

Table 3—Maximum Factors and Equations

Physical Features: A roller diameter of one-third the arm length ($R/R_R = 6$) is a satisfactory proportion. The following series of arm lengths involves a standard series of roller-bearing follower sizes and is used in this study:

R(in.)	$2R_R$(in.)	R/R_R
2⅛	¾	5 2/3
3	1	6
4¼	1½	5 2/3
6	2	6
8½	3	5 2/3
12	4	6

Designations of physical features are shown in Fig. 1.

Roller Capacity and Allowable Torque: The critical element governing allowable torque in nearly all cases is the roller, Fig. 2. From four to nine-point Genevas, it appears that all other elements can be made strong and stiff enough to develop the full capacity of the roller. With three-point, Genevas, the wheel shaft, and with more than nine-point Genevas, the arm shaft, may be critical because they must be overhung.

At the point of maximum ratio of loads, Fig. 3, roller capacity f_a at speed N_R, and wheel radius r determine allowable torque t_a on the wheel, Fig. 4.

Fig. 3 was used in this study, and is based on ratings of McGill roller-bearing cam followers. For rollers that have other ratings, allowable forces on roller, and torques, may be modified in direct proportion to the roller ratings.

Selection and Design: Use Table 3 and the following procedure for selecting a Geneva and for determining the loads on its various elements.

1. *Type*: For driving a dial, the type depends on the number of stations, and the gearing, if any. For all drives, the type depends on the desired time cycle and gearing, and perhaps on the permissible acceleration of the load.

2. *Time Cycle*: Select a type from Table 2, and calculate the arm speed.

3. *Acceleration*: From Table 3, calculate angular acceleration of arm, and convert to linear acceleration on load.

4. *Moment of Inertia on Wheel*: Calculate from load (and include wheel).

5. *Maximum Torque from Inertia on Wheel*: Calculate from Table 3.

6. *Friction (or Constant) Torque on Wheel*: Calculate from load (and include any noninertial load as in hoisting weight).

7. *Total Maximum Torque*: The sum of the two.

8. *Size*: First step is to determine arm length from Fig. 4.

9. *Center Distance, Wheel OD and Overall Dimensions*: Calculate accurately from wheel equations, Table 1. Note: Arms 8½ in. and longer should not be operated above 80 rpm because the rollers will exceed their maximum rated speeds.

10. *Total Maximum Torque on Arm, and Maxi-*

Table 1—Equations for Geneva Motions

Arm

Torque, Friction Load

$$T_F = t_F\,\omega_1 \tag{1}$$

Torque, Inertia Load

$$T_I = I\Omega^2(\omega_1\,\alpha_1) \tag{2}$$

Power, Friction Load, Avg Overall

$$\mathrm{A}\ \frac{N t_F}{974{,}000}$$

Power, Friction Load, Avg Indexing

$$\left(\frac{A}{B}\right)\frac{N t_F}{5250}$$

Power, Inertia Load, Avg Overall = 0

Power, Inertia Load, Avg Accelerating, (hp)

$$\left(\frac{1}{B}\right)\frac{I(\omega_{1-max})^2 N^3}{16{,}720}$$

Wheel

Radius

$$r = \frac{R}{k/\sqrt{l}}$$

$$r_{min} = R\,\frac{1-k}{k}$$

$$r_{max} = \frac{R}{\tan A}$$

$$\text{Note: OD} = 2\sqrt{(r_{max})^2 + R_R{}^2}$$

Displacement

$$\phi = \tan^{-1}\frac{k\sin\theta}{1-k\cos\theta} \tag{3}$$

$$\phi_{max} = 0.01745\,A$$

Velocity

$$\omega = \Omega\,\frac{k\cos\theta - k^2}{l} = \Omega\,\omega_1 \tag{4}$$

$$\omega_{avg} = \Omega\,\frac{A}{B}$$

$$\omega_{max} = \Omega\,\frac{R}{r_{min}} = \Omega\,\frac{k}{1-k}$$

Acceleration

$$\alpha = \Omega^2\,\frac{(k-k^3)\sin\theta}{l^2} = \Omega^2\,\alpha_1 \tag{5}$$

$$\alpha_{avg} = \omega_{max}\,\frac{\Omega}{\theta_{max}}$$

α_{max} occurs when

$$\cos\theta = \frac{-(1+k^2) + \sqrt{(1+k^2)^2 + 32\,k^2}}{4k}$$

$\alpha = 0$ when $\theta = 0$

$$\alpha = \Omega^2\,\frac{R}{r} = \Omega^2 \tan A \text{ at } \theta_{max}$$

Torque, Friction Load

$$t_F = f_F r = f_F\,\frac{R}{k/\sqrt{l}} \tag{6}$$

Torque, Inertia Load

$$t_I = I\alpha = I\Omega^2\alpha_1 \tag{7}$$

Power (Same as Arm)

Roller

Velocity

$$\Omega_R = \Omega\,\frac{R}{R_R}\left(\frac{\sin\theta}{\sqrt{l}}\right) \tag{8}$$

$$\Omega_{R-max} = \Omega\,\frac{R}{R_R} \text{ and occurs at } \theta_{max}$$

$$\Omega_{R-avg} = \Omega\,\frac{r_{max} - r_{min}}{\theta_{max}}$$

Force, Friction Load

$$f_F = \frac{t_F}{r} = \frac{t_F k}{R\sqrt{l}} \tag{9}$$

$$f_{F-max} = \frac{t_F}{r_{min}} \text{ and occurs at } \theta = 0$$

Force, Inertia Load

$$f_I = \frac{t_I}{r} = \frac{I}{R}\left(\frac{\alpha k}{\sqrt{l}}\right) = \frac{I\Omega^2}{R}\left(\frac{\alpha_1 k}{\sqrt{l}}\right) \tag{10}$$

f_{I-max} occurs when

$$\cos\theta = \frac{-(1+k^2) + \sqrt{(1+k^2)^2 + 60\,k^2}}{6k}$$

Table 2—Characteristics of Geneva Motions

Reference Equations	Characteristics	Values						
	n	3	4	5	6	7	8	9
	$2A$ (deg)	120	90	72	60	51 3/7	45	40
	$2B$ (deg)	60	90	108	120	128 4/7	135	140
	$2B/360$	1/6	1/4	3/10	1/3	5/14	3/8	7/18
	Maximums: Locations and values, when $\Omega = 1$:							
3	Max ϕ (deg) =	60	45	36	30	25 5/7	22 1/2	20
	At θ/θ_{max} (per cent) =	100						
4	Max ω and							
1	Max T_F occur when							
	$\omega_{1\text{-}max}$ (rad per sec) =	6.45	2.41	1.425	1.000	0.765	0.620	0.520
	At θ/θ_{max} (per cent) =	0						
5	Max α and							
7	Max t_I occur when							
	α_1 (rad per sec^2) =	31.5	5.46	2.32	1.35	0.913	0.690	0.554
	At θ/θ_{max} (per cent) =	16.0	26.7	32.3	38.2	43.8	47.5	50.6
8	Max Ω_R occurs when							
	Factor $\sin \theta/\sqrt{l}$ =	1						
	At θ/θ_{max} (per cent) =	100						
9	Max f_F and Max r occur when							
	Factor $k/\sqrt{l}$ =	6.45	2.41	1.425	1.000	0.765	0.620	0.520
	At θ/θ_{max} (per cent) =	0						
10	Max f_I occurs when							
	Factor $\alpha_1 k/\sqrt{l}$ =	178.1	11.44	3.10	1.192	0.585	0.354	0.260
	At θ/θ_{max} (per cent) =	13.5	22.0	28.1	33.3	37.8	41.3	43.7
2	Max T_I occurs when							
	Factor $\omega_1 \alpha_1$ =	160	9.68	2.32	0.990	0.525	0.315	0.200
	At θ/θ_{max} (per cent) =	11.5	20.0	25.0	28.0	30.5	33.0	35.0

Table 3—Maximum Factors and Equations

Factors are the expressions bracketed [ ]. For values of all factors, see Table 2.

Equations	Equation Numbers
Acceleration of wheel:	
$a_{max} = \Omega^2 [\alpha_{1\text{-}max}] = 0.01096\, N^2 [\alpha_{1\text{-}max}]$	(11)
Inertia torque on wheel:	
$t_{I\text{-}max} = I \alpha_{max} = \frac{J}{32} \alpha_{max}$	(12)
Inertia torque on arm:	
$T_{I\text{-}max} = I\Omega^2 [\omega_1 \alpha_1]_{max}$ $= 0.000343\, J N^2 [\omega_1 \alpha_1]_{max}$	(13)
Velocity of wheel:	
$\omega_{max} = \Omega [\omega_{1\text{-}max}] = 0.1047\, N [\omega_{1\text{-}max}]$	(14)
Friction torque on arm:	
$T_{F\text{-}max} = t_F [\omega_{1\text{-}max}]$	(15)
Friction force on roller:	
$f_{F\text{-}max} = \frac{t_F}{R} \left[\frac{k}{\sqrt{l}} \right]_{max}$	(16)

Equations	Equation Numbers
Inertia force on roller:	
$f_{I\text{-}max} = \frac{I\Omega^2}{R} \left[\frac{\alpha_1 k}{\sqrt{l}} \right]_{max}$ $= 0.000343 \frac{J N^2}{R} \left[\frac{\alpha_1 k}{\sqrt{l}} \right]_{max}$	(17)
Total torque on wheel:	
$t_{max} = t_{I\text{-}max} + t_F$	(18)
Total torque on arm:	
$T_{max} < T_{I\text{-}max} + T_{F\text{-}max}$	(19)
At $T_{I\text{-}max}$, $T_F \approx 0.8\, T_{F\text{-}max}$	
At $T_{F\text{-}max}$, $T_I = 0$	
Assume, $T_{max} = T_{I\text{-}max} + 0.9\, T_{F\text{-}max}$	(20)
Total force on roller:	
$f_{max} < f_{I\text{-}max} + f_{F\text{-}max}$	(21)
At $f_{I\text{-}max}$, $f_F \approx 0.9\, f_{F\text{-}max}$	
At $f_{F\text{-}max}$, $f_I = 0$	
Assume, $f_{max} = f_{I\text{-}max} + f_{F\text{-}max}$	(22)

mum Torques from Inertia and Friction: The latter exceeds the former because they do not occur at the same time nor in the same direction. Calculate the two and combine them according to the assumption in Table 3.

11. *Total Maximum Force on Roller, and Maximum Forces from Inertia and Friction*: The two differ as in Step 10, but the difference is less. Calculate the two and use their sum.

12. *Loads on Bearings of Arm and Wheel*: Calculate from the roller force and the dimensions of the ultimate design.

13. *Power*: The required power for acceleration is regained during deceleration, net zero. Power to overcome friction (or constant load) is consumed during the entire indexing time. Calculate from Power Formulas, Table 1, or from time cycle and load.

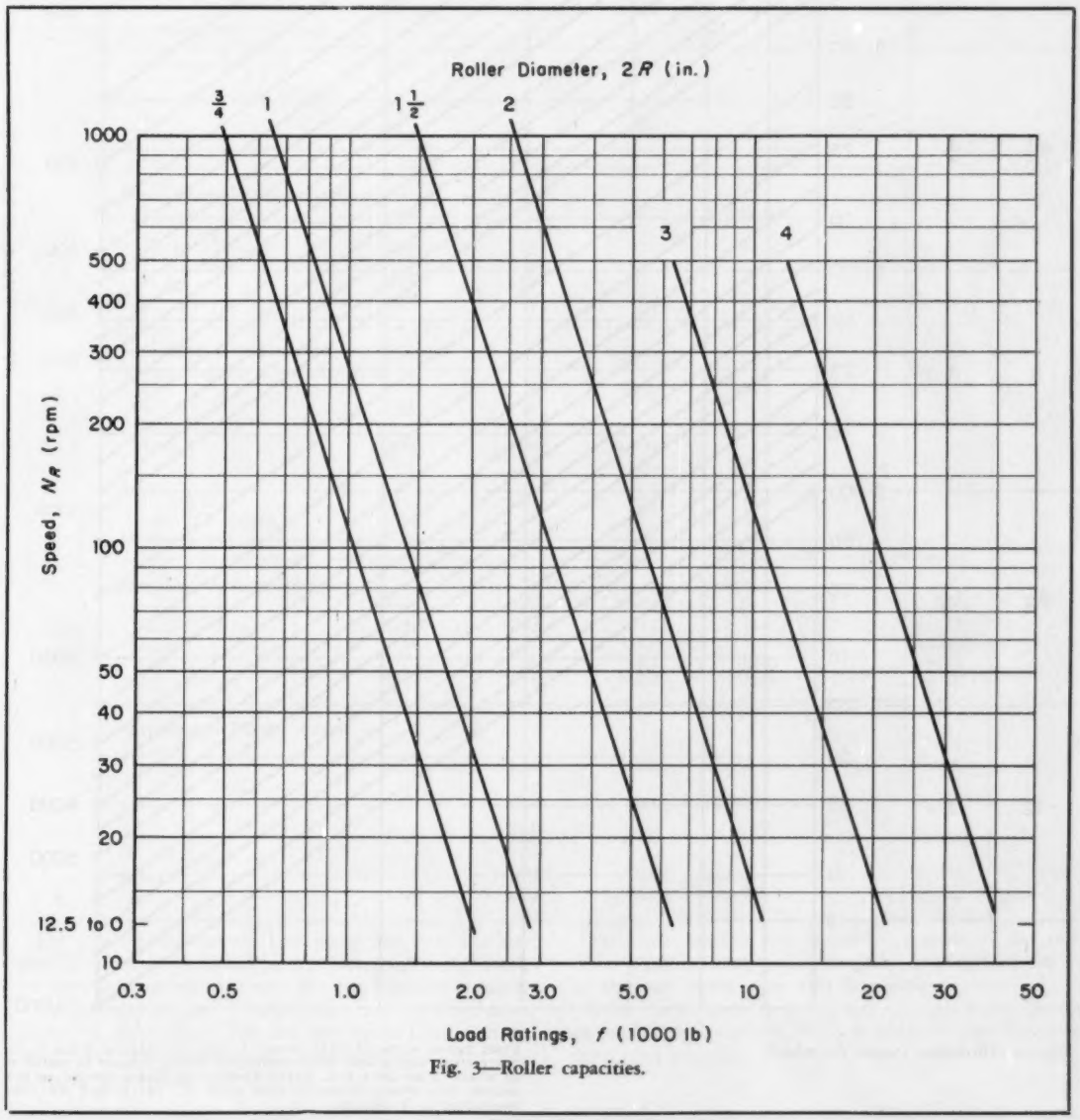

Fig. 3—Roller capacities.

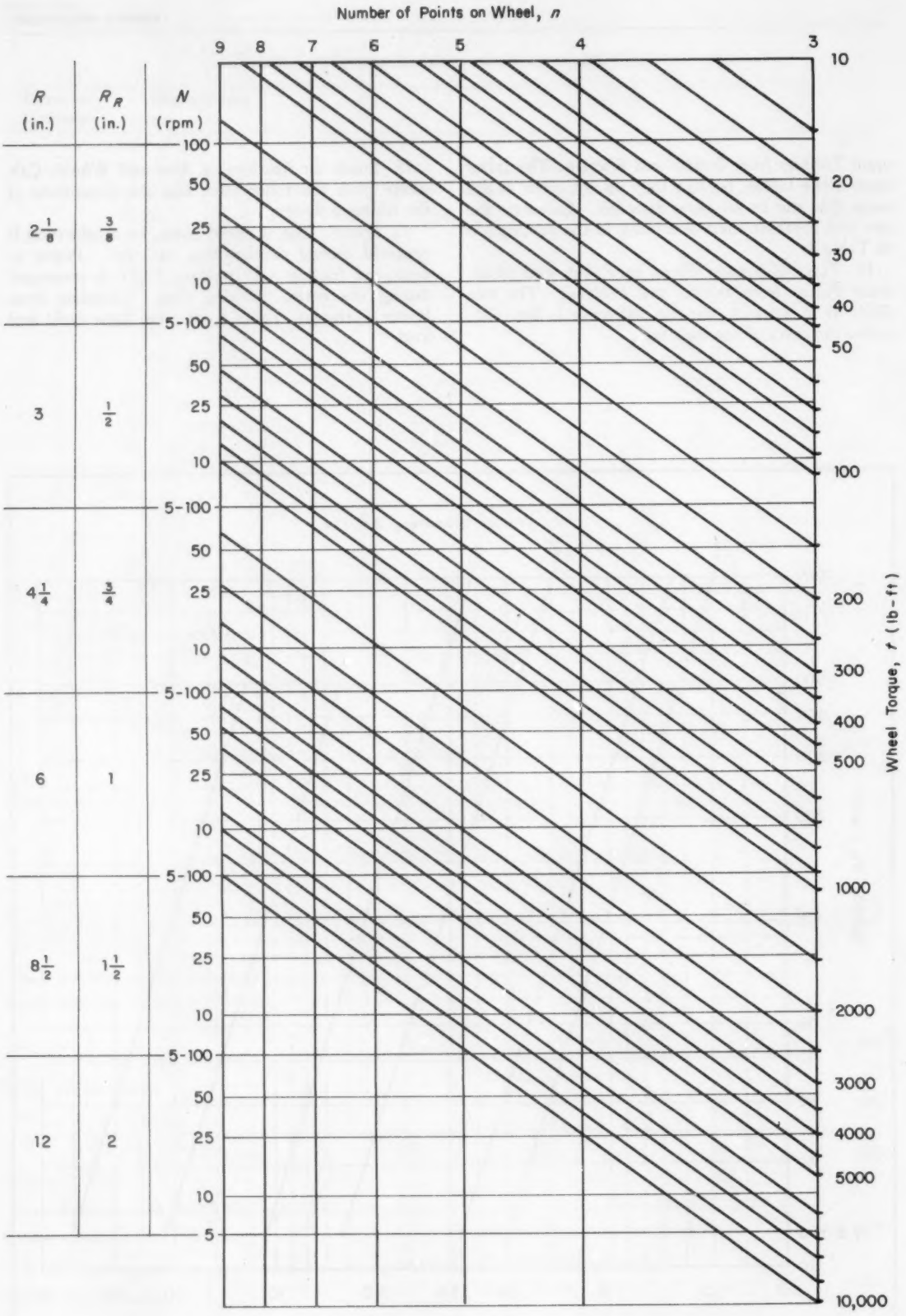

Fig. 4—Allowable torque on wheel.

From known value of wheel torque t, move on diagonal t-line to its intersection with a line which designates known number of points n on wheel. Move on n-line, in the direction of higher torque, to the nearest line which designates arm speed N. Use R and R_R corresponding to N selected.

Examples

Assume a conveyor operation that includes a vertical lift and involves the following: Conveyor movement between stations, $S = 2$ ft; total weight of conveyor and work, $W = 50$ lb; constant force from conveyor while indexing, $F = 10$ lb, of which 8 lb is weight of work being lifted, and 2 lb is friction load of conveyor; work time (conveyor stationary) is 1.5 sec, and index time is subject to the Geneva chosen.

Obtain results for three-point, four-point, and six-point Genevas.

Characteristics	Values			Units	Ref.
Points	3	4	6		
Cycle					
$2A$	120	90	60	deg	Table 2
A	60	45	30	deg	
Work time	1.5	1.5	1.5	sec	Given
Index time/Work time	1:5	1:3	1:2		Table 2
Index time	0.3	0.5	0.75	sec	
Cycle time	1.8	2.0	2.25	sec	
N	33.3	30.0	26.7	rpm	
Maximum Acceleration					
$\alpha_{1\text{-}max}$	31.5	5.46	1.35	rad per sec^2	Table 2
α_{max}	383	53.9	10.52	rad per sec^2	Eq. 11
Equivalent radius of load $\rho = \frac{S}{\pi}\left(\frac{180}{2A}\right)$	0.955	1.273	1.910	ft	
Linear acceleration of load $\frac{\alpha_{max}\,\rho}{32}$	11.4	2.14	0.628	ft per sec^2	
Maximum Wheel Torque					
$J = W\rho^2$	45.6	81.1	182.5	lb-ft^2	
$t_{I\text{-}max} = \frac{J}{32}\alpha_{max}$	546	136.8	60.1	lb-ft	Eq. 12
$t_F = F\rho$	9.55	12.7	19.1	lb-ft	
t_{max}	556	150	79.2	lb-ft	Eq. 18
Size and Dimensions					
Torque and type lines interest at					Fig. 4
R	6	3	2 1/8	in.	
N_a	21	38	150	rpm	
Relative to N_a, N is	Higher	Lower	Lower		
R	8 1/2	3	2 1/8	in.	Text
$2R_R$	3	1	3/4	in.	Text
$C = R/k \approx$	9 3/4	4 1/4	4 1/4	in.	
Wheel OD approx.	10 1/4	6	7 3/4	in.	
Height approx.	25	10 3/4	10 1/2	in.	
Maximum Arm Torque					
$(\omega_1 \alpha_1)_{max}$	160.0	9.68	0.990		Table 2
$T_{I\text{-}max}$	2780	242	44.2	lb-ft	Eq. 13
$\omega_{1\text{-}max}$	6.45	2.41	1.000		Table 2
$T_{F\text{-}max}$	62	31	19.1	lb-ft	Eq. 15
T_{max}	2836	270	61.4	lb-ft	Eq. 20
Maximum Roller Force					
$\left[\frac{\alpha_1 k}{\sqrt{l}}\right]_{max}$	178.1	11.44	1.192		Table 2
$f_{I\text{-}max}$	4360	1144	300	lb	Eq. 17
$\left[\frac{k}{\sqrt{l}}\right]_{max}$	6.45	2.41	1.000		Table 2
$f_{F\text{-}max}$	87	123	108	lb	Eq. 16
f_{max}	4447	1267	408	lb	Eq. 22

The accelerations indicate how gentle the four and six-point Genevas are compared to the three-point, even though the three-point acceleration may not be considered excessive,

The size and dimension values show that the three-point Geneva is much larger than the four or six-point Geneva. Wheel and arm torques, and roller forces, indicate considerably larger shafts and bearings.

The cycle speed of the four-point is about 10 per cent slower than the three-point. Six-point cycle speed is about 20 per cent slower than the three-point.

If its cycle speed is acceptable, the four-point Geneva appears to be the choice. It is probably the least expensive and easiest to make.

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Scale model illustrated built to 3.5 mm scale.

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[illegible] Railway & Power Eqp. Corp., Ltd. [illegible] Copperweld Steel Tubing Company, 285 Broadway, New York 7, New York

High temperature capabilities of . . .

Pneumatic Actuating Systems

W. J. KOERNER
Project Engineer
The Marquardt Corp.

THE ability of pneumatic actuation systems to operate at extremes of temperature makes them attractive for many applications. In particular, the nutating disc type positive - displacement pneumatic motor is applicable to high-temperature environments and high-response requirements.

Types of Systems: High-temperature pneumatic actuation systems can be divided into three types: Packaged, boost, and direct. The packaged system has its own energy source and is most often used for an emergency or auxiliary system. The boost system increases the energy level of the ram or bleed air by means of pressure and temperature transformation. The direct system uses energy from ram air or compressor bleed air and multiplies this air by motor and mechanical means at the actuator to the force level required. This article considers the direct type.

Capabilities: The present apparent temperature limit for simple hydraulic actuation systems is 500 F. A number of programs are presently being conducted in an attempt to increase the operating temperature. These programs are generally utilizing new synthetic base fluids. A few programs are attempting to use liquid metals.

Current state-of-the-art advances in hydraulics require the use of heavy, costly cooling systems to forestall thermal instability and breakdown of lubricating qualities of the fluid for application at temperatures in excess of 500 F.

Advantages: Problems of sealing are few. In fact, an increasing number of high-temperature pneumatic actuation systems are being designed with no rubbing seals. Close-tolerance parts and labyrinth-sealing techniques may reduce leakage flow to approximately 10 per cent of displacement flow.

The low viscosity of air at low temperature will permit excess leakage across labyrinth-type seals. At elevated temperatures, however, air has higher viscosity than most hydraulic fluids. The narrow viscosity range of air over a wide temperature range is important because the more constant fluid metering reduces variations in control characteristics with changes in temperature.

Air offers several side advantages: It does not deteriorate when exposed to nuclear radiation, there is no fire hazard, there are no unpleasant or toxic fumes, and there are no gum residues.

Developments: The three most important contributions to the present position of pneumatics are: Advanced stabilization techniques, the positive-displacement air motor, and improved materials.

STABILIZATION TECHNIQUES: One of the most important stabilization techniques uses plenum chambers or additional volumes of air isolated from the servo actuator piston or air-motor chamber by restrictors. These chambers smooth the response and improve system stability by absorbing high-frequency oscillations. The sizing of the restrictors, as well as the plenum-chamber volume, is determined by "tuning" the loop to obtain desired damping. This restrictor-chamber combination is called a "transient flow stabilizer" since pressure drop occurs across the restrictor only during transients. Other proven methods of compensating for the inherent sponginess of air include rate and acceleration feedback.

POSITIVE-DISPLACEMENT AIR MOTOR: New types of positive-displacement motors for high-temperature pneumatic use include the cam-piston, gear, and nutating-disc types. The positive-displacement nonexpansion cycle motor predominates because it assures maximum utilization of space and weight, and results in maximum torque per unit of displaced volume. This cycle pro-

vides high response and rapid reversal, making such motors well suited to modulating systems.

An air motor based on the principle of the nutating disc appears promising. The nutating disc principle is exemplified in the common domestic water flow meter. The movable element in this type of motor is a flat disc attached to a central sphere and mounted in an annular chamber which has a spherical sidewall bounded by conical upper and lower surfaces. The plate is prevented from rotating about its own axis such that when subjected to a differential pressure, a nutating motion is executed. Rotary power is obtained by means of a "Z" crank.

In this type of motor, output torque is a direct function of the volumetric displacement and differential pressure across the disc. The air-weight flow increases at essentially a constant rate with speed, and is directly proportional to the differential pressure. As mass-flow density increases, throttling, or porting losses become the dominant factor is over-all efficiency. This tends to limit positive-displacement motors to relatively low speeds. The characteristics of the nutating-disc motor tend to reduce throttling losses. Since there is no internal valving, the only unavoidable line restriction is the controlling servo valve. By geometry of construction, the porting of the motor may be essentially as large as the connecting lines.

A study of the kinematics of the nutating-disc motor indicates that the output torque of a single-element motor is essentially constant. Positive starting of the motor in any angular position is assured. The use of multiple elements, therefore, becomes a design choice for envelope, response, or dynamic balance at high speeds.

Materials: Selection of materials grows in importance due to increase in the temperature of operating gases and lengthened operating life of pneumatic systems. Considerations in the selection of materials are:

1. System loads, their method and rate of application and their variations with temperature.
2. Strength to weight ratio at operating temperatures with special consideration for creep, deflection, package size, etc.
3. Compatibility with environment; for example, oxidation, radiation, etc.
4. Friction and wear characteristics.
5. Coefficients of thermal expansion.
6. Thermal conductivity and emissivity.
7. Ease of fabrication.

Materials presently being used at 1200 F gas temperature are: A 286, S 816, Haynes Stellite No. 3, 16, 19, 6B, and No. 25 Alloy, M 252, J 1570, Udimet 500 and titanium carbide.

Research: Literature surveys in the field of high temperature wear and friction properties reveal that a definite lack of data applicable to the wear problems in high-temperature, nonlubricated machine design. The most desperate need, and that which is presently limiting the growth of high-temperature pneumatic actuation systems, is high-temperature wear and friction data. Some proprietary efforts at obtaining these data are under way and will undoubtedly assist in advancing the operating temperature. However, a comprehensive basic research program is needed to determine the mechanism of wear and optimum material combinations.

SAE Paper No. 107U presented at the SAE Aeronautical Meeting, Los Angeles, October, 1959, 8 pp.

electrical

Performance and Shapes Of Permanent Magnets

P. P. Cioffi, Bell Telephone Laboratories

Relative merits of two permanent-magnet configurations. Total magnetic circuit permeance is, for all practical purposes, independent of permanent-magnet configuration. Only the division of permeance between magnet and pole pieces is affected by configuration. This is to be expected since the major contribution to permeance derives from the polar regions. Magnet configuration determines whether the predominance of this surface resides in the magnet or in the pole pieces.

AIEE Paper No. 59-1120, "Relation Between Permanent Magnet Configuration and Performance," presented at the AIEE Fall General Meeting, Chicago, October, 1959, 5 pp.

hydraulic

Boundary Layer Theory Applied To Nozzle and Venturi Flow

G. W. Hall, Senior Lecturer, Royal Military College of Science

A simple rational method for the analytical determination of discharge coefficients for the rounded-entrance nozzle and Venturi, covering the entire Reynolds number range. Certain experimental results, when compared with the theoretically derived curves, support the method. Tentative explanations are given, with the aid of the theory, for a number of puzzling and disturbing features arising from the results of some recent flowmeter calibrations. The analysis includes a new method of plotting the discharge coefficient against Reynolds number.

"Application of Boundary Layer Theory to Explain Some Nozzle and Venturi Flow Peculiarities," prepared for the Institution of Mechanical Engineers (Great Britain), 8pp.

management

Controlling Drafting Costs

Harry M. Perks, Day & Zimmerman Inc.

An accounting system for control of costs in a design organization of 75 to 300 men, divided into squads of 6 to 12.

The first step in the system is establishment of a Code of Accounts. Each number in the code identifies a part of an engineering project.

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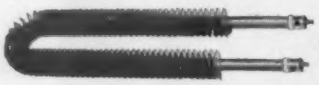

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historical records on which future estimates are based.

"Drafting Costs Can Be Controlled," presented at the Drafting Management Institute, University of Wisconsin, Madison, Wis., October, 1959, 10 *pp.*

mechanical

Applications of the Cycloid In Machine Design

E. Pollitt, Senior Research Engineer, Armour Research Foundation, Chicago.

How the several cycloidal motions are matched to particular design requirements. The multilobed epicycloid has sharply pointed cups. A motion having this path is desirable in the operation of folding of flexible materials like paper or cloth. With the epicycloid, the motion can be produced by uniformly moving elements. It is used extensively in newspaper folders. In stack feeders this motion is desirable for suction cups which pick up the individual articles from the stack. An epitrochoidal cam constrained to perform a wobble motion is a highly efficient, compact, speed reducer. Other applications of cycloidal motion are function generators, indexing devices, pumps, and straight-line linkages.

ASME Paper No. 59-A-134, *"Some Applications of the Cycloid in Machine Design," presented at the Annual Meeting, Atlantic City, N. J., November-December,* 1959, 8 *pp.*

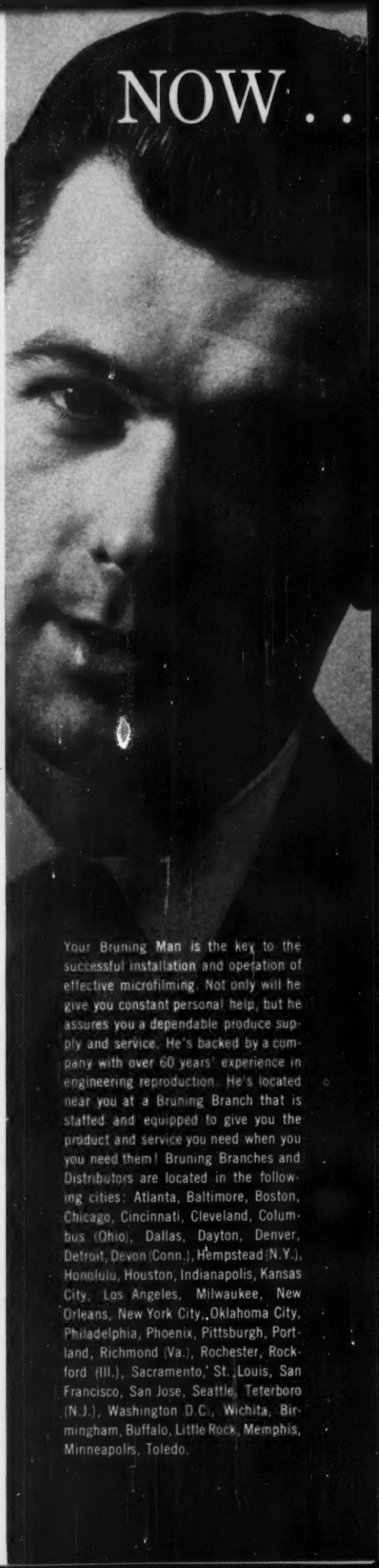
processes

Gas-Shielded Metal-Arc Welding of Magnesium

C. R. Sibley, Air Reduction Sales Co.

Results of two recent studies in the field of magnesium arc welding. One study led to a solution of the problem of oxide formation on magnesium welding wire. Heavily oxidized welding wire had proved unsatisfactory because the current could not be transferred easily and uniformly to the wire. A new contact tube was designed. The new tube has a series of interior wires which are fastened at the inlet end and float at the outlet end. The insert wires are free to move under the force of wire cast or electromagnetic fields. This movement creates a wiping action at the points of electrical contact.

The second study indicated that control of the melting rates of mag-



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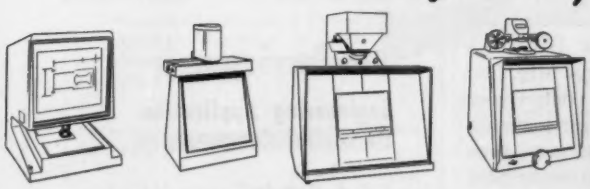

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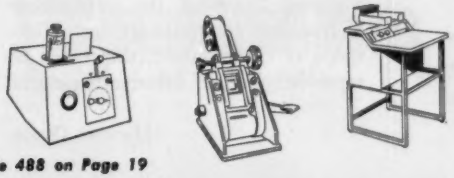
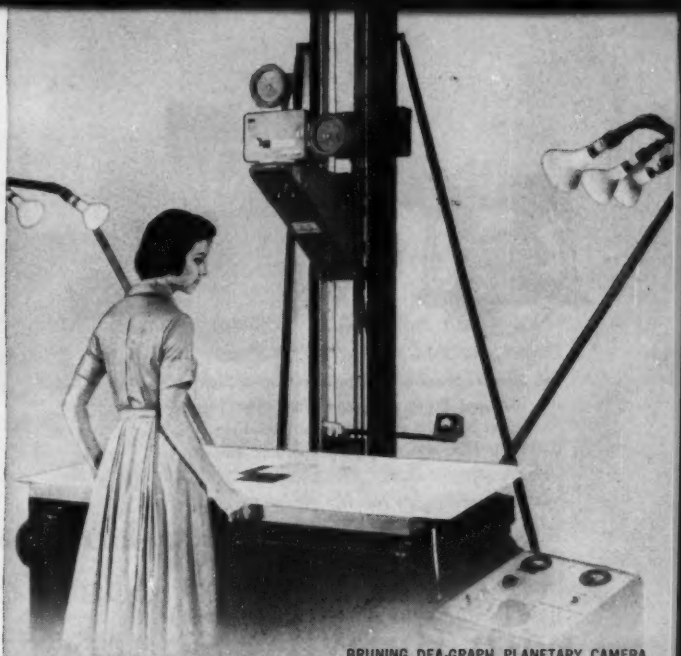


Circle 488 on Page 19



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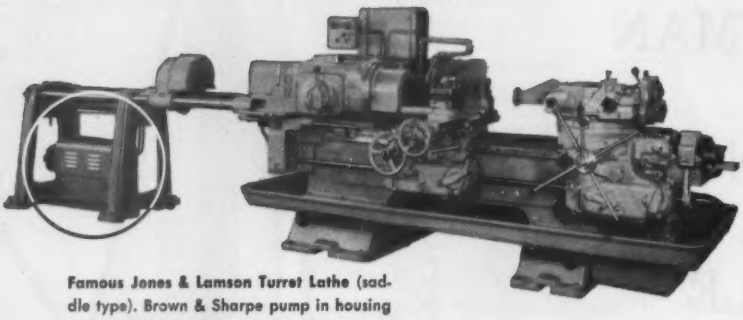
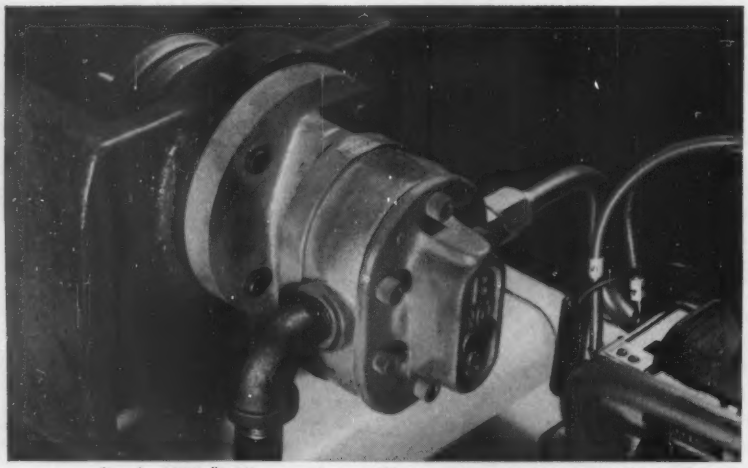


Famous Jones & Lamson Turret Lathe (saddle type). Brown & Sharpe pump in housing under bar feed mechanism (left) helps move stock fast, with minimum operator effort.

How Jones & Lamson designers held costs down with Brown & Sharpe pumps



Standard B&S #1-S Pump, with special flange mounting, is built into each J&L unit. It has quiet helical gears, and needle type antifriction bearings.

Problem: Designers of this lathe needed a dependable pump in the hydraulic unit of the bar feed mechanism. This unit gives "fingertip" control in advancing and chucking stock to be machined. The pump must provide oil pressures to 500 psi, at a capacity of 3¾ gpm; and be flange-mounted and direct coupled to an 1800-rpm motor. Preferably, it should be a "stock" pump, for minimum cost.

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nesium welding wire is possible but not yet commercial. Experiments with steel and aluminum welding wire have been shown to be valid for magnesium. Lowering the melting rate of aluminum and steel has been accomplished by using liquid or dust coatings of emissive agents on the welding wire surface.

"New Developments in the Gas-Shielded Metal-Arc Welding of Magnesium," presented at the 15th Annual Convention of the Magnesium Association, New York, Oct. 19-20, 1959, 3 *pages.*

Fabrication with Adhesives

A. J. Slosser, Mgr., Industrial Adhesives, Armstrong Cork Co.

Design considerations in adhesive joining of metals and rigid plastics. Guiding practices are:

1. Minimize stress on the adhesive.
2. Stress the adhesive in the direction of its maximum strength.
3. Minimize stress in the direction the adhesive is weakest.
4. Make the maximum proportion of bonded area contribute to the strength of the assembly.
5. Maintain continuity of bond.
6. Be adaptable to production techniques.

Major factors influencing the choice of design of metal-to-metal and rigid plastic joints are duration, magnitude, and direction of the load to be applied to the joint. Since most of the adhesives used for bonding metal to metal are relatively rigid, strong in shear, and weak in peel or cleavage, joints usually are designed to place the adhesive in shear and prevent or minimize peel or cleavage stresses.

Presented at the Industrial Adhesives Applications Institute, University of Wisconsin, Madison, Wis., October, 1959, 15 *pp.*

techniques

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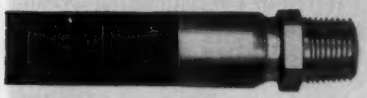

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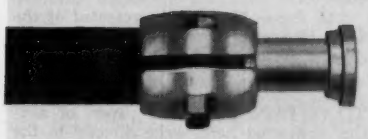

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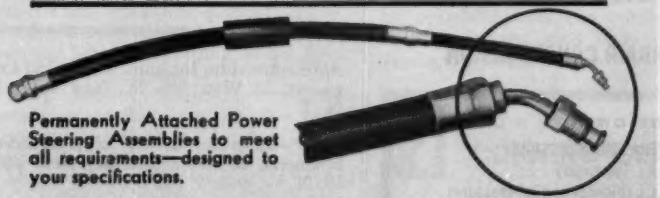

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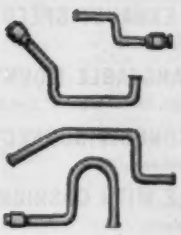

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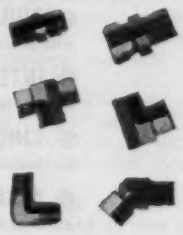

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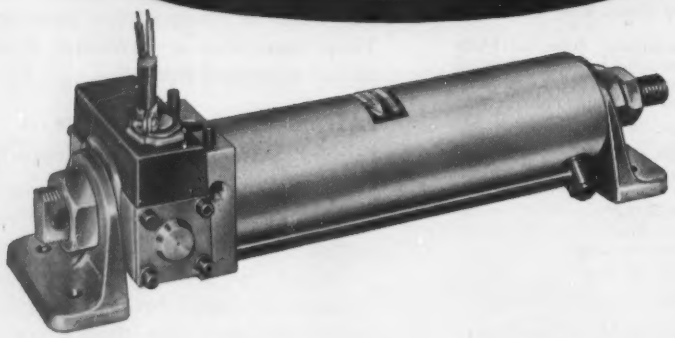


Here's a combination that's hard to beat—a performance-proved industrial air cylinder with its own built-in directional and exhaust speed control valves—in a single, compact "package". Check these important features:

- **BUILT-IN DIRECTIONAL CONTROL VALVES...** your choice of four control combination; double solenoid, single solenoid with button bleeder return, double button bleeder, or double remote pilot pressure operation.
- **BUILT-IN EXHAUST SPEED CONTROLS** with automatic Nylon lock.
- **INTERCHANGEABLE MOUNTINGS...** front or rear flange, low or high "L" foot brackets, rod and cylinder clevis.
- **SINGLE CONDUIT CONNECTION** for double solenoid unit.
- **AVAILABLE WITH CUSHIONED STOP** either or both ends.
- **PERFORMANCE-PROVED MODERNAIR CONSTRUCTION**

Condensed Specifications

DIAMETERS: 1½", 2", 3"
ROD SIZES: ½", ⅝", ¾"
MIN. OPERATING PRESSURE: 20 p.s.i.
SOLENOID POWER REQUIRED: 10 watts
MAX. OPERATING PRESSURE: 150 p.s.i. (solenoid) 200 p.s.i. (bleeder or pilot pressure)
SOLENOID COILS AVAILABLE: (ac) 8-10, 110, 220 v. (dc) 12, 24, 30 v.

Call your local MODERNAIR sales outlet (see Modernair trademark under "CYLINDERS" in the yellow section of your phone book) or write us today for complete data bulletin; please address Dept. E-1

Modernair CORPORATION
400 Preda Street · San Leandro, California
MEMBER NATIONAL FLUID POWER ASSOCIATION

high order of accuracy.

Efficient use of machine computation in engineering requires two things: Acceptance by engineers and supervisors of an engineering philosophy which can profitably use computation, and overcoming the high cost of computer programming.

Obtaining acceptance for machine computation is essentially an educational problem which must be undertaken by the engineering societies and industry itself. The high cost of programming can be alleviated, at least in the short term, by the adoption of universal computer languages in conjunction with program libraries. Program exchange permits a company to obtain the use of many programs in exchange for some which it has produced.

ASME Paper No. 59-A-180, presented at the Annual Meeting, Atlantic City, N. J., November-December, 1959, 3 pp.

Methods of Estimating Shock and Vibration

C. T. Molloy, Space Technology Laboratories Inc.

How to anticipate performance of structures under shock and vibration in the design stage before physical measurements are possible. Equations are derived to show the response of a pure mass to steady state excitation, random excitation, and shock excitation, such as produced in aircraft.

SAE Paper No. 100W, presented at the SAE National Aeronautic Meeting, Los Angeles, October, 1959, 10 pp.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

AIEE—American Institute of Electrical Engineers, 33 West 39th St., New York 18, N. Y.

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y.

The Institution of Mechanical Engineers, 1 Birdcage Walk, Westminister, London, S.W., 1.

The Magnesium Association, 122 East 42nd St., New York 17, N. Y.

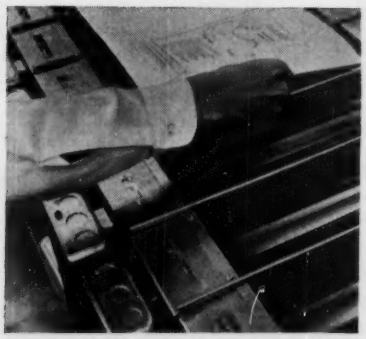
SAE — Society of Automotive Engineers Inc., 485 Lexington Ave., New York 17, N. Y.

University of Wisconsin, University Extension Div., 3030 Stadium, Madison, Wis.

THIS IS GLASS

A BULLETIN OF PRACTICAL NEW IDEAS FROM CORNING

HOW TO GET MORE USEFUL HEAT PER KW



It's not much to look at, but our new VYCOR Brand Radiant Heater is loaded with advantages for those involved with drying, baking, curing or pre-heating.

The basic appeal of this unit is the kind of heat it gives you—*long wave;* efficient because it's readily absorbed.

These long waves are emitted from wire coils enclosed in tubes of 96% silica glass. And the tubes (made from one of our rugged VYCOR brand glasses) resist heat, heat shock, and corrosion.

Long wave output is just one reason why your kilowatts will yield more useful heat. This heater also has a reflector *system* that includes a platinum strip bonded to one side of the tubing, and two layers of aluminized steel with Fiberglas insulation in the housing.

Result: Between 85 and 90% of the available radiation is directed to your work.

With VYCOR Brand Radiant Heaters mounted horizontally above or below your process line, you average 20 watts per square inch of working space and get full heating (800-850°F) in three minutes, so there's no costly warm-up delay. These units cool quickly, too, so you don't need complex equipment for diverting heat after shutting off the line.

Heating tubes come in 14″, 26″, 38″ and 54″ lengths, mounted in twos or fours. You get each unit complete with frame, reflector sheet, junction box, mounting hangers and leads.

More facts? Use the coupon.

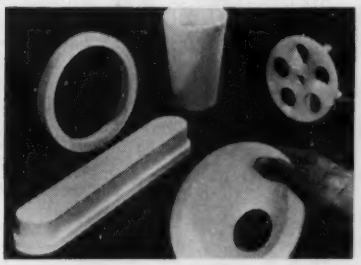
NEW MATERIAL FOR MISSILE MAKERS AND OTHERS WITH HIGH-TEMPERATURE PROBLEMS

The biggest drawback to fused silica, despite its many desirable thermal and electrical properties, has been the limitation on sizes and shapes available.

No more. Now Corning comes up with Multiform Fused Silica—a combination of a unique process and a versatile material.

With Multiform Fused Silica you can put the useful properties of fused silica to work in shapes and sizes that previously were unattainable.

For example, you can now have cylinders, domes, crucibles, rods and slabs—in sizes equal to any achieved by conventional ceramic forming processes.



Corning's new Multiform Fused Silica offers the unique thermal and electrical properties of fused silica in shapes and sizes that up to now were considered impractical.

Softening point for this new material is 2880°F; you can design for *long-term* use at temperatures over 1770°F, intermittent up to 2250°F.

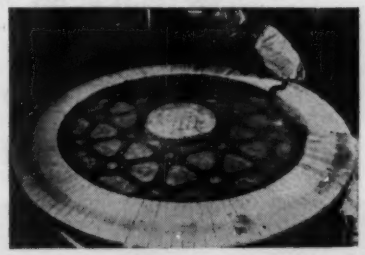
Resistance to thermal shock is high, since coefficient of expansion is 3×10^{-7} per degree F.

This new material also displays an extremely stable dielectric constant and a low loss tangent over a broad temperature range. Example: At a frequency of 8.6×10^9 cps, the dielectric constant is 3.58 at 77°F and 3.57 at 750°F.

Through either slip-casting or dry pressing you end up with an object (a radome, perhaps?) that has an opaque, fine-grained structure machinable to tolerances of plus or minus .001 inch.

For samples of and/or detailed specs on new Multiform Fused Silica, mark the coupon and send it to our New Products Division.

A MIRROR FOR THE STARS



This is a glass telescope mirror blank that measures 84 inches across and weighs 4,000 lbs.

We made it. And we did it with a new process in which solid chunks of glass were placed in a mold and *sagged into a single piece* under intense heat.

Back in the thirties we also made some big mirrors. But then we ladled molten glass into molds and came up with a 200-inch disk for the Hale Observatory on Mt. Palomar and a 120-incher for the Lick Observatory.

Our new sagging approach improves quality. It also costs less and is less complicated.

Seven months the disk was annealed. Now at the Kitt Peak Observatory in Arizona, grinding and polishing will go on for an estimated 24 months. Final polishing will be done after the telescope is fixed on a star. Time for that? Another year.

Leading us to these facts: Patience is part of the art of the astronomer. And Corning can do almost anything with glass—be it a "one-shot," hand-tailored piece or *mass production of small items at a very rapid pace.*

Find out for yourself. The basic references are "This is Glass" and Bulletin IZ-1, "Designing with Glass for Industrial, Commercial and Consumer Applications."

Or outline your need in whatever detail seems feasible. Could be your star is just around the corner, with glass by Corning.

CORNING MEANS RESEARCH IN GLASS

CORNING GLASS WORKS 52 Crystal St., Corning, N. Y.

Please send me: ☐ "Corning Industrial Heaters"; ☐ Information on Multiform Fused Silica; ☐ "This is Glass"; ☐ Bulletin IZ-1

Name..... Title.....

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Helpful Literature

for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Electronic Voltmeters

Bulletin 7004A describes the Model 15A alternating current electronic voltmeter with a frequency range of 100 cycles to 300 kilocycles and 12 ranges from 1 mv to 300 v. This portable battery-operated instrument weighs only 6 lb. 2 pages. Consolidated Electrodynamics Corp., Alectra Div., 325 N. Altadena Dr., Pasadena, Calif. L

Circle 641 on Page 19

Snap-Action Switches

Sealed, high temperature, and shock resistant types of snap-action Micro Switches for aircraft, missile, and missile ground handling equipment are described and illustrated in Data Sheet 151. Dimensional drawings and electrical ratings are included. 4 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill. K

Circle 642 on Page 19

Remote Control System

Recent issue of "Application Notes" describes a transistorized remote control system, diagramming certain components and including schematic drawings. Specifications are included, along with adjustment suggestions. 8 pages. Texas Instruments Inc., Semiconductor-Components Div., Box 312, Dallas, Tex. P

Circle 643 on Page 19

Silicone Rubber

Product and application data on the complete family of RTV (room temperature vulcanizing) silicone rubber compounds are contained in Bulletin CDS-170A. Compounds are used for potting and encapsulating electric and electronic equipment, as well as for high and low temperature sealing and for flexible mold making. 12 pages. General Electric Co., Silicone Products Dept., Waterford, N. Y. C

Circle 644 on Page 19

Wire Products

Various types of Prentiss iron and steel wire, nonferrous wire, wire specialties, detachable head spools, and wire coils are outlined in illustrated folder. A wire gage table is included. 6 pages. H. K. Porter Co., Riverside-Alloy Metal Div., Holyoke, Mass. B

Circle 645 on Page 19

Aerospace Fasteners

Single panoramic illustration in this chart-fold bulletin shows wide variety of external and internal threaded fasteners for the aerospace industry. Included are shear, engine, airframe tension, and titanium bolts, locknuts, plate nuts, and others. Brief data on each are given. 8 pages. Standard Pressed Steel Co., Box 102, Jenkintown, Pa. C

Circle 646 on Page 19

Printed Circuit Tapes

Available forms of Brady self-sticking printed circuit tapes in black photographic and red see-through types are listed in revised Bulletin 163-2. Also offered are terminal circles, connector strips, and various stock and special shapes. Dimensions of each are given. 2 pages. W. H. Brady Co., 727 W. Glendale Ave., Milwaukee 9, Wis. K

Circle 647 on Page 19

Pressure Cutoff

Compact PE-103 pressure cutoff simultaneously controls pressure data from up to 30 channels and as many different pressures, acting like a 30-pole, single-throw switch. It has two stator plates, each with 30 pressure ports and a 6-in. length of stainless steel tube soldered into each port. A rotor between the two plates provides the on-off action. Unit is described in Bulletin 103. 2 pages. Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif. L

Circle 648 on Page 19

Reinforced Polyester

Case history bulletin provides information on a application of Thermaflow 100, a reinforced polyester molding compound. Used in a centrifugal pump, it offers chemical resistance and certain assembly and other advantages. Molding data is supplied. 4 pages. Atlas Powder Co., Chemicals Div., Wilmington 99, Del. C

Circle 649 on Page 19

Hydraulic Fitting

Self-coined metal-to-metal seal, straight thread, hydraulic fitting, subject of illustrated Catalog M-57, requires no swing radius or special tools for installation. Its specifications, sealing principle, and available forms are covered. 4 pages. Flodar Corp., 16911 St. Clair Ave., Cleveland 10, Ohio. G

Circle 650 on Page 19

Speed Recorders

Type HF differential speed strip-chart recorders are usable for indicating and recording differential speed on process equipment. Operating principle as well as typical applications are detailed in Bulletin GET-2741-1A. 2 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 651 on Page 19

Miniature Power Pack

The new Transpac miniaturized solid-state power pack is offered with output voltages from 6 to 32 v at 0 to 2 amp. They operate on 105 to 125 v, 60 to 400 cycle ac. Features and performance data are listed in Catalog Sheet 118. 1 page. Electronic Research Associates, Inc., 67 Factory Place, Cedar Grove, N. J. D

Circle 652 on Page 19

Steel Collars

Sixteen basic ways to use steel collars in moving parts or machinery are explained by text and pictures in Folder 2554. They are made in 45 sizes with diameters from 1/16 to 3 in. Each has an Unbrako self-locking setscrew. 6 pages. Standard Pressed Steel Co., Jenkintown, Pa. C

Circle 653 on Page 19

Cold Finished Shapes

Advantages offered through use of Custom cold finished special shapes in making parts are related in illustrated bulletin. Practically any desired cross section can be produced in carbon, alloy, and tool steel rods or bars to exact tolerances. 4 pages. H. K. Porter Co., Vulcan-Kidd Steel Div., Aliquippa, Pa. E

Circle 654 on Page 19

Typed Symbols

A method for using an electric typewriter for fast, convenient typing of special symbols and equations needed in the field of engineering is subject of Bulletin R 8964.6. Through the use of interchangeable type heads, the typist can insert special type characters in the machine in seconds. Hundreds of characters are shown. 12 pages. Sperry Rand Corp., Remington Rand Div., 315 Fourth Ave., New York 10, N. Y. D

Circle 655 on Page 19

Heat Exchanger Tubes

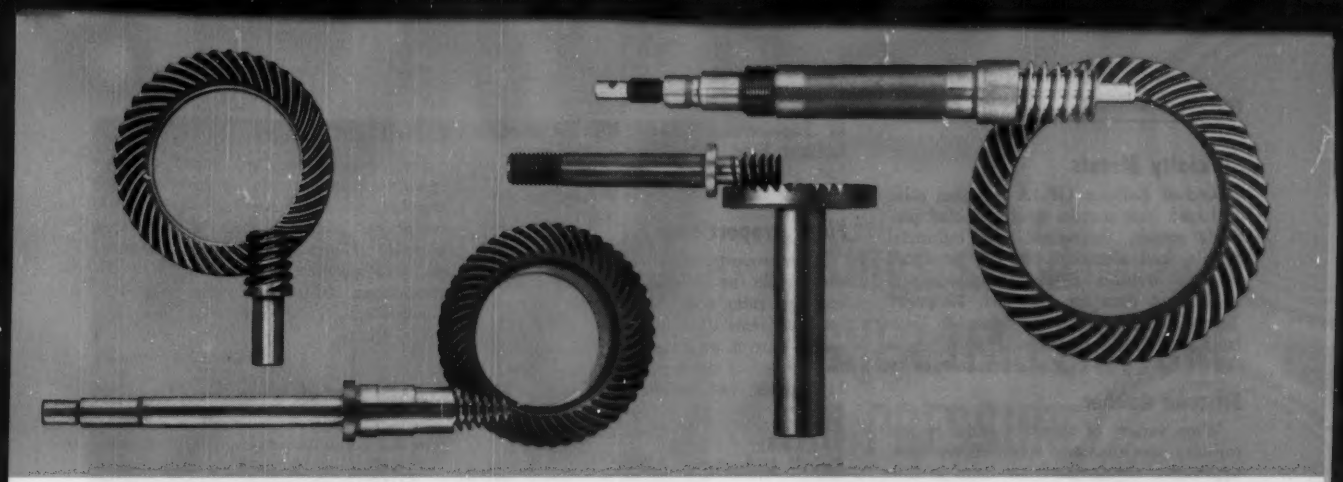
Prepared for engineers associated with the design and manufacture of heat exchanger equipment, Bulletin TB-431 contains complete data on Lectrosonic heat exchanger tubes. This line of welded steel tubing offers equal or better service than seamless type at a savings up to 32.2 per cent, according to bulletin. 8 pages. Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Pa. G

Circle 656 on Page 19

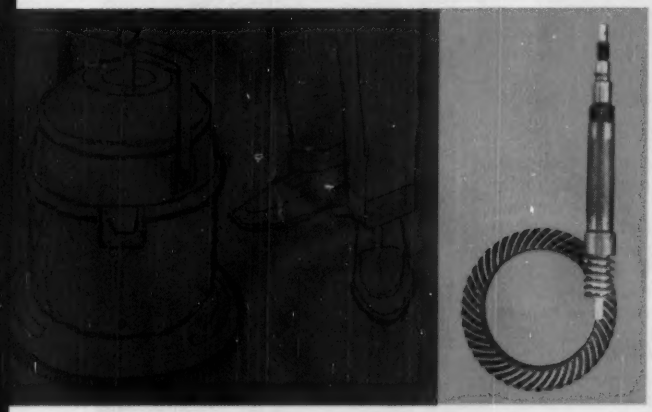
Wiring System

Wyr-Way swing out panels for electric controls can be used as modules in complete control cabinets. They provide both a mounting surface and flexible wiring channels. Full details are given in illustrated bulletin. 4 pages. Wyr-Way Inc., Rochester 3, N. Y. N

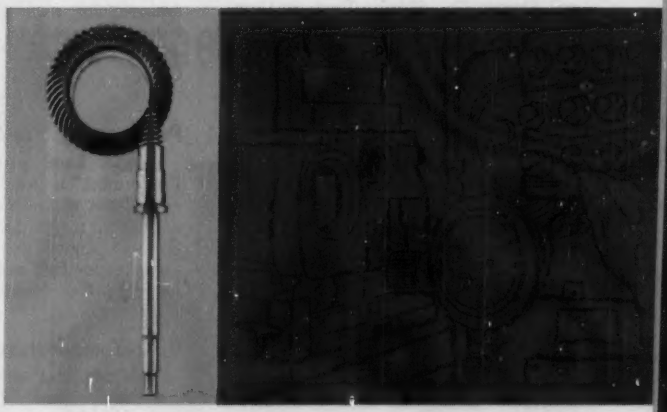
Circle 657 on Page 19



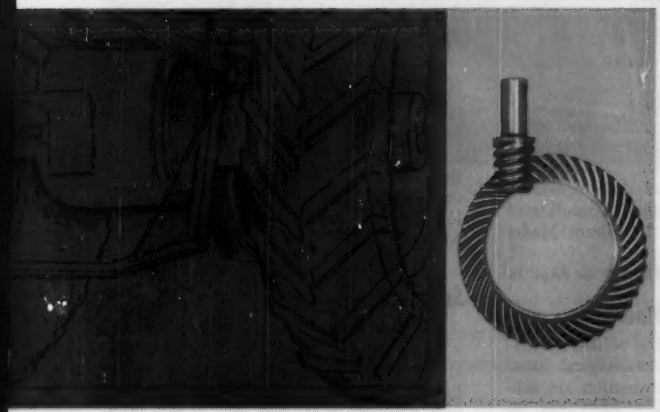
WHICH OF THESE HIGH-RATIO HYPOIDS IS "JUST RIGHT" FOR YOUR PRODUCT?



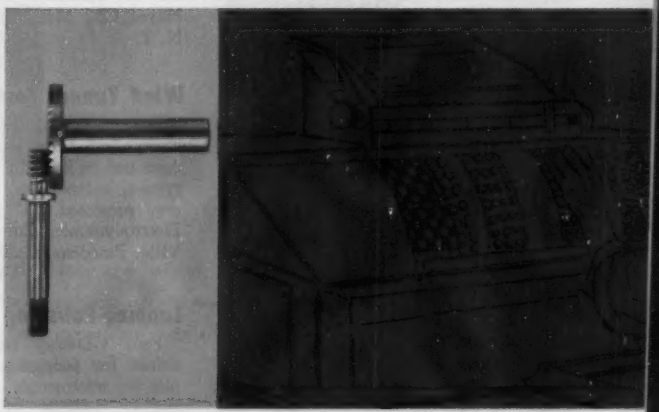
For hand tools. Where space is a problem—as in portable tools like this one—the high offset lets you design a more compact unit. Choose just the offset to solve your design problem with a more flexible, more compact unit than the corresponding worm and wheel.



. . . or machine tools. This high-offset pair lets you combine high reduction with strength, compactness and other advantages you might find profitable in designing machine tools. High-ratio hypoids can be produced on Gleason equipment for ratios of 1:10, 1:40 or even higher.



Big and strong. Where you need strength—as in farm machinery—high-offset hypoid pinions (with teeth which tend to "wrap around") are larger and stronger than corresponding bevel pinions. An extended shank on cylindrical pinions makes very rigid straddle mountings practical.



. . . or small and smooth. For smooth operation—as in office equipment that must run quietly—high-offset pairs provide smooth, quiet tooth action. Because teeth "wrap around" the pinion, you get continuous action—even with just one or two teeth! Grinders are available for applications requiring precision finish.

High-offset or high-ratio hypoids can be cut, tested, and quenched on the same Gleason equipment that is used on more familiar spiral bevel and hypoid gears. You can get more information about Gleason high-ratio hypoid gears by writing for free literature. Submit your prints for recommendations.

GLEASON WORKS

1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

Circle 493 on Page 19

Specialty Metals

Revised Bulletin GP-1A describes solid and clad base metals, solid and clad precious metals, thermostat and industrial metals, and electrical contacts produced by this division. Brief descriptions and application data are included. 10 pages. Texas Instruments Inc., Metals & Controls Div., Attleboro, Mass. B

Circle 658 on Page 19

Silicone Rubber

Wide variety of standard industry and military specifications which cover most application requirements are listed in Bulletin CDS-188 on silicone rubber. Aid in selecting the specifications for particular requirements is provided. 8 pages. General Electric Co., Silicone Products Dept., Waterford, N. Y. C

Circle 659 on Page 19

Digital Data Recorder

Bulletin 350-8 is descriptive of the automatic Multipoint digital data recording system. Up to 100 input selector modules can be used to provide handling capacity for 1000 input variables. 2 pages. Datex Corp., 1307 S. Myrtle Ave., Monrovia, Calif. L

Circle 660 on Page 19

Railway Car Batteries

Form 5010 is entitled, "Maintenance Manual for Exide Batteries in Railway Air Conditioning and Car Lighting." Procedures for keeping batteries operating at top efficiency are discussed. Chart lists capacities of various batteries. 12 pages. Electric Storage Battery Co., Exide Industrial Div., Rising Sun & Adams Avenues, Philadelphia 20, Pa. E

Circle 661 on Page 19

Precision Switches

Series 3MN precision two-circuit switches are rated 15 amp and are UL-listed for up to 600-v ac service. They have a life of over 10 million operations. They are particularly suited for limit or control use on machine tools and industrial equipment. Full information is given in Data Sheet 164. 2 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill. K

Circle 662 on Page 19

Filter Elements

Performance data on seven basic filter element materials and variety of filter assemblies and replacement elements are content of illustrated bulletin. Materials offer particle size control from ½ to 250 microns in service temperatures from −350 to 1500° F. 2 pages. Bendix Aviation Corp., Bendix Filter Div., 434 W. 12 Mile Rd., Madison Heights, Mich. H

Circle 663 on Page 19

Permanent Magnets

Having the greatest coercive force in the Alnico family, Alnico VII A is an improved permanent magnet material that is especially suited for core type meters and instruments. Magnetic and material characteristics, as well as demagnetization and energy product curves, are contained in Engineering Bulletin 351. 2 pages. Indiana Steel Products Co., Valparaiso, Ind. J

Circle 664 on Page 19

Flow Proportioner

Flow proportioners described in Bulletin G-3 divide the hydraulic fluid input at a constant ratio and are available in sizes for flow rates up to 120 gpm. The governed flow is adjustable over a range of 95 per cent of the input. 2 pages. Brand Hydraulics, 144 S. 38th St., Omaha 31, Nebr. I

Circle 665 on Page 19

Small Inductors

Data Sheet I 8-5 lists specifications of torodial inductors with inductance values from 1 millihenry to 7 henries. They are designed for stacking or printed circuit boards. 1 page. Arnold Magnetics Corp., 4613 W. Jefferson Blvd., Los Angeles 16, Calif. L

Circle 666 on Page 19

Postforming Plastics

"Shaped Laminated Parts by Low-Cost Postforming" is title of reprint which tells what types of laminated plastics are recommended for postforming, discusses mold design, and gives correct temperatures and pressures for best results. 4 pages. Taylor Fibre Co., Norristown, Pa. E

Circle 667 on Page 19

High Temperature Alloy

Two technical bulletins cover vacuum induction melted Wasp̃aloy and M-252 superalloys, developed for corrosive and heavy duty high temperature uses. Chemical composition, physical constants, mechanical properties, heat treatment and finishing data, and application information are included. 8 pages each. Kelsey-Hayes Co., Metals Div., New Hartford, N. Y. N

Circle 668 on Page 19

Wind Tunnel Testing

Instrumentation for acquiring and processing data from wind tunnel testing is described in Bulletin 3020. Details of the system, components, and their operation are presented. 4 pages. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif. L

Circle 669 on Page 19

Lapping-Polishing Machines

Four vibratory lapping-polishing machines for preparing metallurgical samples for microscopic examination are subject of Bulletin 57631-8. Machines remove tedium of hand polishing. 2 pages. Syntron Co., 260 Lexington Ave., Homer City, Pa. F

Circle 670 on Page 19

Hydraulic Check Valves

Cone type hydraulic check valves for 3000-psi service are available with flow ratings to 50 gpm. Design and application information are given in two Catalog File Sheets 1517A 12 and 13. 1 page each. Parker-Hannifin Corp., Parker Hydraulics Div., 17325 Euclid Ave., Cleveland 12, Ohio. F

Circle 671 on Page 19

Centrifugal Pumps

Two metal stampings bolted together to form a housing which encloses a welded impeller assembly comprise Series 2000 centrifugal pumps, subject of illustrated bulletin. Design options, available models, and specifications for the 10 to 90-gpm, 10 to 100-ft head pumps are given. 4 pages. R. S. Corcoran Co., Box 1404, Joliet, Ill. J

Circle 672 on Page 19

Copper Plated Wire

Uses of Copperply copper plated steel wire for communications wire, drop wire, guy and messenger strand, lashing wire, and other applications are detailed in illustrated Bulletin 203. Specifications and properties are presented. 8 pages. National Standard Co., Niles, Mich. T

Circle 673 on Page 19

Sensing Control

Electronic sensing control, detailed in Bulletin 400, detects, counts, measures, and recognizes objects as they enter a capacity field. Method of operation, details of components, 16 applications, and four diagrams are among contents. 2 pages. Security Controls, Inc., 503 Franklin St., Buffalo 2, N. Y. N

Circle 674 on Page 19

Tape Recorders

The 100 Series of Ampex instrumentation magnetic tape recorders is subject of Booklet FR-100B. Performance figures for direct, FM, pulse duration modulation, and digital recording are included. Accessories suit the modular machine to many individual requirements. Various applications are shown. 20 pages. Ampex Data Products Co., 934 Charter St., Redwood City, Calif. M

Circle 675 on Page 19

Electronic Chronograph

Time between events is measured to a resolution of 20 millimicroseconds with an accuracy of one part in 100 million per day by the Quantizer electronic chronograph. Its operational characteristics and technical specifications are found in Bulletin 104A. 2 pages. Computer Equipment Corp., 1931 Pontius Ave., Los Angeles 25, Calif. L

Circle 676 on Page 19

Suspension Scale

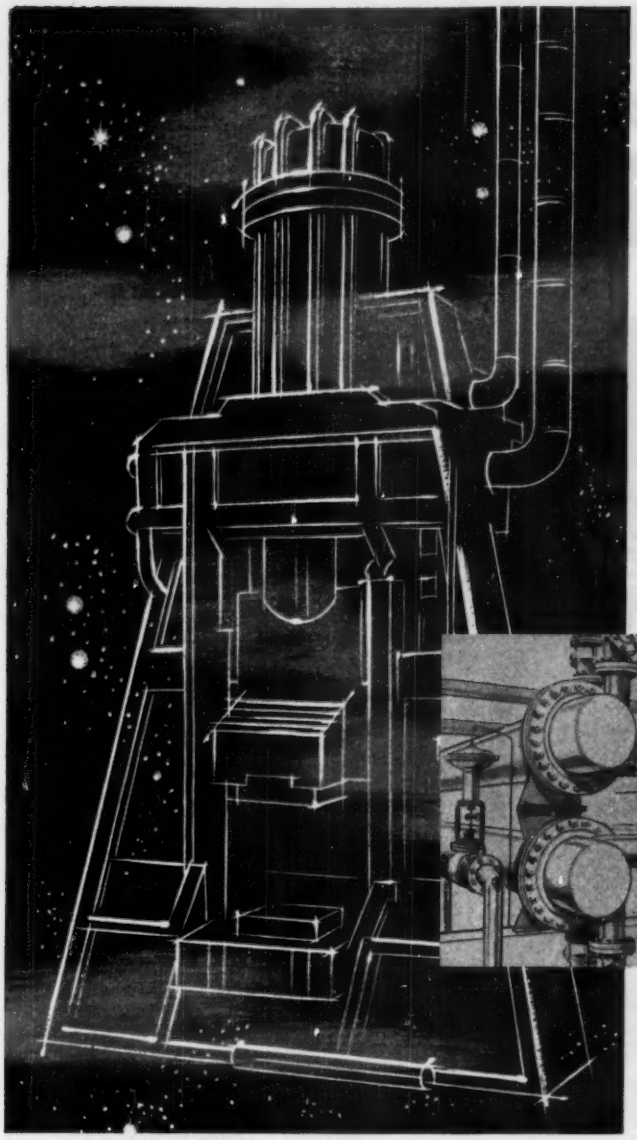
Construction details, specifications, and a wide range of applications for the Model P suspension scale are contained in illustrated Bulletin 58E. They have a sealable accuracy of 0.1 per cent of full scale capacity. Seven models have capacities from 250 to 10,000 lb. 8 pages. W. C. Dillon & Co., Box 3008, Van Nuys, Calif. L

Circle 677 on Page 19

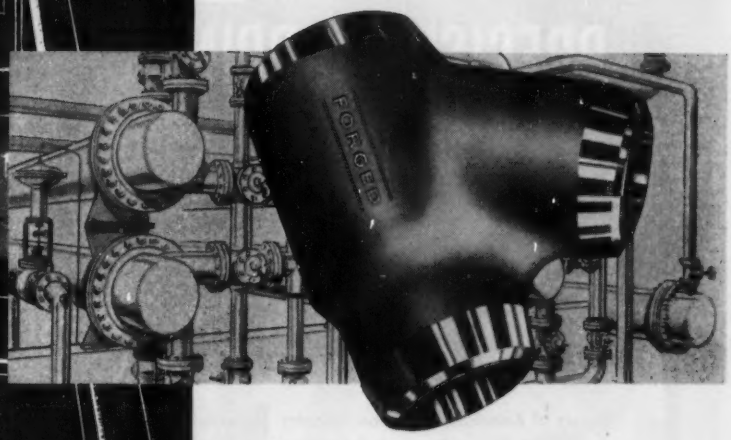
Boiler Water Gages

Stream area shows in red and water area shows in green in Refracolor high pressure boiler water gages, described and illustrated in Data Sheet 360. Specifications of the low maintenance units are given. 2 pages. Jerguson Gage & Valve Co., 80 Adams St., Burlington, Mass. B

Circle 678 on Page 19



Fittings stand HIGHER TEMPERATURE and PRESSURE when designed to be FORGED



Modern steam-powered forging hammer

Vital fittings in refineries and chemical plants are forged, for only forgings can provide maximum strength required without excess weight. Fabrication is simpler, hanging and supporting are less expensive, life of fittings under severe operating conditions is extended.

The hammer-compacted metallurgical structure of forged parts gives superior performance in containing gases or liquids under high temperatures or pressures, vibration, high-velocity fluid flow and corrosion.

Design *any* vital parts to be forged... strength/weight ratios are higher, as-assembled costs are lower, performance is better. Literature to help you design, specify, and procure forged parts will be sent on request.

When it's a vital part, design it to be FORGED

Drop Forging Association • Cleveland 13, Ohio

Names of sponsoring companies on request to this magazine

Giants of American instrument industry, including such firms as . . .

- Bulova Research & Development Laboratories, Inc.
- Eclipse Pioneer, Division of Bendix Aviation Corp.
- Federal Telecommunication Laboratories, Inc.
- General Electric Co.
- Sperry Gyroscope Co.

and many others think of CHATILLON, when instrument design calls for the "world's most accurate spring".

CHATILLON . . . the leading manufacturer of precision springs is particularly proud of the improved performance record of instruments using the noteworthy CHATILLON developed temperature-compensated alloy "Iso-Elastic". The hysteresis error of this remarkable spring is less than .05% of deflection. Drift does not exceed .02% of deflection in 5 minutes. These characteristics plus temperature compensation insure the ultimate in precision spring production.

CHATILLON makes Extension, Spiral, Torsion, Compression and Form Springs of Iso-Elastic material, as well as springs of all conventional alloys.

To find out how "the World's Most Accurate Spring" can better your product and for engineering bulletins, write CHATILLON SPRING DIVISION.

*U.S.A. Pat. No. 2174171

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85 CLIFF STREET, NEW YORK 38, N.Y.
Manufacturers of Scales, Force Measuring Instruments and Precision Springs Since 1835

HELPFUL LITERATURE

Recording Oscillograph

Up to 50 channels of static or dynamic data are recorded by the Type 5-119 recording oscillograph, described in illustrated Brochure 1536. Its electronic flash timing system, specifications, and accessories are detailed. 16 pages. Consolidated Electrodynamics Corp., 360 Sierra Madre Villa, Pasadena, Calif. M

Circle 685 on Page 19

Germanium Diodes

Germanium gold-bonded diodes, detailed in Brochure GD-40, are built to strict mechanical, electrical, and hermetic seal standards. Specifications and characteristic forward and reverse curves are included. 10 pages. General Transistor Corp., 91-27 138th Place, Jamaica 35, N. Y. D

Circle 686 on Page 19

Flow Meter

Integral by-pass is featured in the low cost, high capacity flow meter briefly covered in Specification Sheet DS-132. Five sizes have water capacities of 5 to 50 gpm and air capacities of 20 to 200 cfm. 1 page. Brooks Rotameter Co., Hatfield, Pa. E

Circle 687 on Page 19

Molded Packings

Palmetto Pyramid V-type molding packing, described in illustrated Manual PY-959, consists of a series of three or more nested rings and sealing rings. Design data, specifications, and suggestions for use are included. 8 pages. Greene, Tweed & Co., North Wales, Pa. E

Circle 688 on Page 19

Servo Valves

Unity-coupled hydromechanical feedback, high null accuracy, and titanium construction are features of Model 6103 servo valves. Their principle of operation, characteristics, and performance curves are content of illustrated bulletin. 4 pages. Kearfott Co., Little Falls, N. J. D

Circle 689 on Page 19

Single Choppers

Synchronous modulator-demodulator functions are performed in single double-pole double-throw choppers. Detailed in Bulletin C-43, they track within 5 electrical degrees. Covered are units for 60 and 400-cps operation. 2 pages. Airpax Electronics Inc., Cambridge Div., Cambridge, Md. C

Circle 690 on Page 19

Insulating Varnishes

Comprehensive Catalog E-IVC on selection and application of electrical insulating varnishes details electrical and mechanical properties and operating temperature limitations. Charts, graphs, and illustrations cover temperature conversion, solvents, specific gravity, viscosity, and other values pertinent to selection. 35 pages. Minnesota Mining & Mfg. Co., Irvington Div., 900 Bush Ave., St. Paul 6, Minn. J

Circle 691 on Page 19

Circle 495 on Page 19

Miniature Might. Tiny Oyster Drills (*Urosalpinx Cinarea*) are noted destroyers of their much larger fellow-mollusks — oysters. One of 80,000 mollusk species, the Oyster Drill feeds on his victims through a shell-piercing snorkel.

Maximum Precision for the entire mechanism of this electric timer is assured by MPB bearings mounted on shaft ends and in gear trains. By reducing torque, these stainless steel bearings mean longer life and less maintenance for the timer.

Man with Miracles. Sales Manager Ken Broman heads MPB Sales Engineers in their engineering and consultative service to industry. One of these highly experienced MPB technical men is always ready to help solve your miniaturization problems.

More Miracles in Miniaturization

ACTUAL SIZE OF BEARINGS USED IN ELECTRIC TIMER SHOWN ABOVE

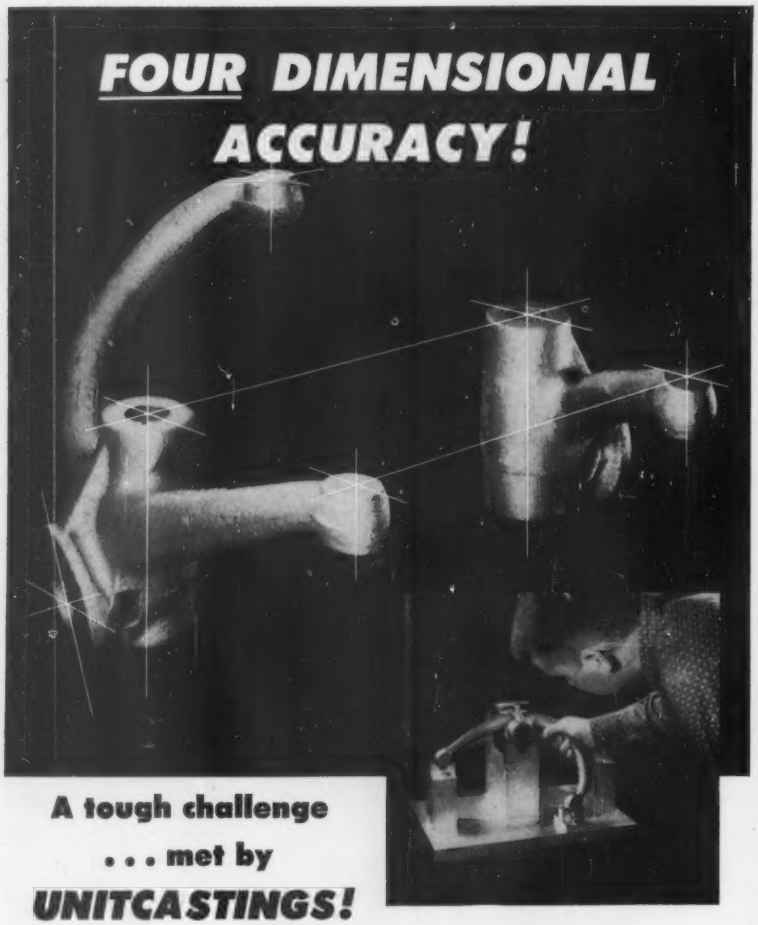
Designing and redesigning to meet modern requirements calls for miniaturization on a grand scale. Components for aircraft or outer space missiles must be reduced to minimum size and weight. Greater precision is needed in complicated, compact mechanisms and expert miniaturization is sought throughout industry. MPB helps you perform miracles in miniaturization by producing over 500 types and sizes of bearings ranging from 3/8" O.D. down to 1/10" O.D., with specials as required. For an illustrated catalog containing complete facts on these bearings, for engineering advice or both, write **Miniature Precision Bearings, Inc.,** 101 Precision Park, Keene, N. H.

MPB

Helps you perform miracles in miniaturization

Circle 496 on Page 19

FOUR DIMENSIONAL ACCURACY!



A tough challenge . . . met by UNITCASTINGS!

Four-way specifications for this pair of steering arms combined tolerances difficult to hold in sand casting. Structural contour, surface limitations and internal consistency are accepted with regularity at Unitcast. However, a fourth requirement, *relationship of extremities* in such an unusual casting design is a tough problem to solve *economically!*

With a reasonable *finished* cost as an objective, Unitcast's quality control specialists recommended an unorthodox molding method. Special pattern equipment was built to control distortion in the spider-like arms . . . metal flow was redirected along with other unusual procedures. Finally, inspection jigs assured delivered accuracy.

Unitcastings *more* than meet customer's requirements and *cost remained competitive!* Unitcast can offer a similar service for your problems . . . call today for a Unitcast Sales Engineer.

UNITCAST CORPORATION, Toledo 9, Ohio
In Canada: CANADIAN-UNICAST STEEL, LTD., Sherbrooke, Quebec

Unitcast

SPECIFICATION STEEL CASTINGS

HELPFUL LITERATURE

Motor Protectors

Hermetically-sealed overheat protectors for refrigeration compressor motors, thermostats for compressor motor winding use, overload protectors, current and thermal type starting relays, and commercial thermostats are among the Klixon controls for air conditioning and refrigeration applications described in illustrated bulletin. 6 pages. Texas Instruments Inc., Metals & Controls Div., Attleboro, Mass. B

Circle 679 on Page 19

Geared Belt Drives

Flexibility of belt drives is combined with the advantages of chain and gear drives in Browning Gearbelt drives. Catalog GB-201-A shows how power is transmitted by engagement of belt teeth with pulley grooves. Installation suggestions, engineering data, specifications, and many stock drive combinations are among contents. 56 pages. Browning Mfg. Co., Maysville, Ky. G

Circle 680 on Page 19

Sealless Pumps

Illustrated Bulletin 1100 covers design, operation, and selection of the proper "canned" pump. Described are sealless Chempumps, suited for handling of a wide variety of fluids. Specifications of models suited for 5000 psi, cryogenic to 1000° F service, are included. 4 pages. Fostoria Corp., Chempump Div., Huntingdon Valley, Pa. E

Circle 681 on Page 19

Formula Control

Manual errors in blending, proportioning, and batching operations are eliminated by putting formulation into the hands of the Formula Capsule, an automatic electronic unit. Data Sheet 5904 describes how the pocket-size unit programs the weighing of up to 24 solid and/or liquid ingredients. 2 pages. Richardson Scale Co., Van Houten Avenue, Clifton, N. J. D

Circle 682 on Page 19

Fasteners

Illustrated Brochure TL 151 describes the complete line of mechanical fasteners and special cold headed parts marketed by the Engineered Fasteners Div. How it can help customers in selecting the best fastener for a specific use is related. Covered are lockbolts, blind rivets, Tuff Tite fasteners, tubular rivets, and clevis pins. 12 pages. Townsend Co., Box 71-Z, Ellwood City, Pa. F

Circle 683 on Page 19

Diesel & Carbureted Engines

Catalog CR-608-I deals with 75 and 95-hp diesel and carbureted 6-cylinder engines which are interchangeable in power and dimensions. Engines are similar in construction, varying mainly in head and piston sections. Booklet points up construction, features, and interchangeability. 12 pages. International Harvester Co., 180 N. Michigan Ave., Chicago 1, Ill. J

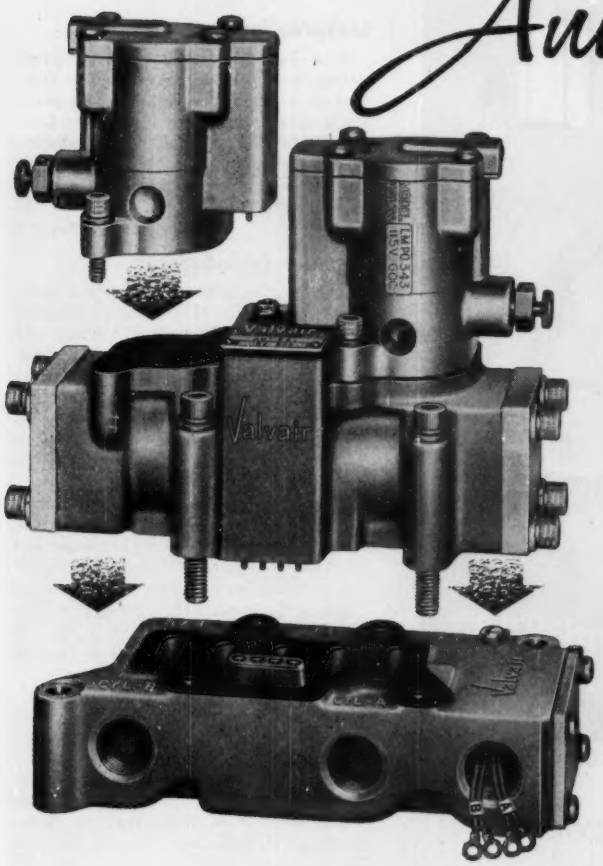
Circle 684 on Page 19

Circle 497 on Page 19

Announcing

VALVAIR®

½" NPT PLUG-IN VALVES



MODEL PB-441 shown. 4-way single or double pilot-operated types, for sub-base or manifold mounting. Aluminum and stainless steel components assure multi-million cycle dependability. Interchangeable pilots, with coils guaranteed against burn-out for life of valve, fit any plug-in Speed King. Coils for ac or dc, any voltage . . . 35 — 200 psi range . . . integral junction box . . . optional manual over-ride, common or separate exhaust ports, sub-base connected external pilot supply . . . ¾ in. exhaust ports, ½ or ¾ in. inlet and cylinder ports . . . valve meets JIC standards.

Based on the service-proved design principle of the Speed King ¼ in. plug-in Valvair's ½ - ¾ in. plug-in valve series provides plug-in convenience and versatility to a wider range of control valve applications.

Electrical and pneumatic circuits are completed automatically when valve and pilot are plugged in . . . bolted down. The result — cost-cutting reduction of original installation and maintenance time. All power connections are made permanently in sub-base or manifold . . . there's no need to disturb piping or wiring for quick in-service maintenance.

What's more, advanced design shortens stroke . . . speeds response. Separate coded (4-wire) circuits on double solenoid models meet JIC requirements. Flow area through valve and sub-base equals that of full ½ in. pipe.

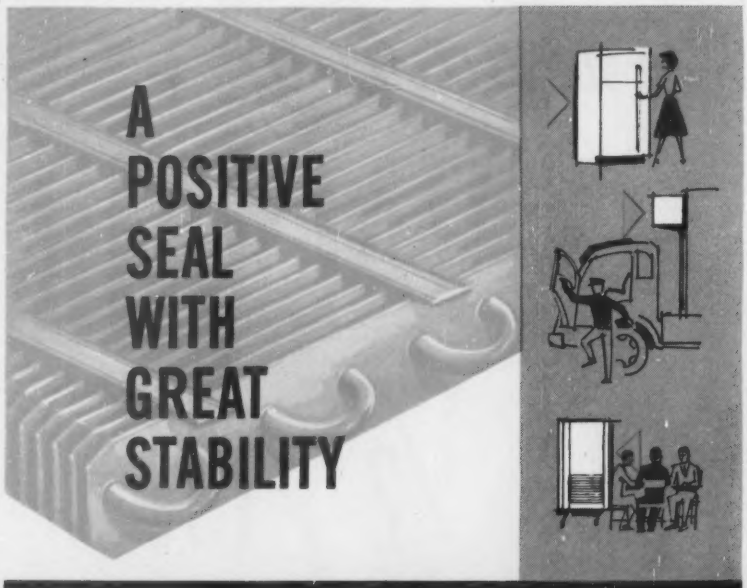
Whether your control valve applications are on the drawing board or now in service, it'll pay you to investigate the advantages of Valvair plug-in design. A call to your near-by Valvair field office will bring prompt application engineering recommendations.

For more information, write for Bulletin SPL. Address Dept. MD-160, Valvair Corporation, 454 Morgan Ave., Akron 11, Ohio

Valvair AKRON 11, OHIO

Other INDUSTRIAL DIVISIONS of IBEC: The Sinclair-Collins Valve Co. The Bellows Co., Akron, Ohio • V. D. Anderson Co., Cleveland, Ohio.

8098



Precision "O" Ring Compound 2337

For Refrigeration Service

SERVICE – PRECISION "O" RING Compound 2337 – a new development – seals effectively against freon or freon and oil combination in refrigerators and air conditioning units.

APPLICATION – For use in couplings, compressors, valves, etc., as either static or dynamic seals.

CHARACTERISTICS – Temperature stability, no shrinkage, positive volume increase in freon or freon and oil mixtures assure sealing and extended service life.

Other related new Precision "O" Rings are now giving low cost, trouble-free service in beverage, food and chemical fields.

Sealing reliability for your product is as close as your phone. Our creative engineering service will help you obtain the **right** product design and will assure the **right** "O" Ring for it. Call for the services of a Precision engineer today.

Precision Rubber Products Corporation • "O" Ring and Dyna-seal Specialists

Box 431, Oakridge Drive, Dayton 7, Ohio Canadian plant at: Ste. Thérèse de Blainville, Québec

HELPFUL LITERATURE

Leakproofing Nuts

How Tef-Seal nuts are used for eliminating leaks on all pipe threads (Dry Seal or standard) in hydraulic and pneumatic systems is related in Bulletin 6170. Specifications, size range, and installation instructions are given. 2 pages. Weatherhead Co., 128 W. Washington Blvd., Ft. Wayne, Ind. H

Circle 692 on Page 19

Pressure Leak Detector

Operating principles, features and application data on the M-60 mass spectrometer detector for locating leaks in vacuum and pressure systems are presented in Bulletin GEZ-2939. Unit employs helium as a tracer gas. 12 pages. General Electric Co., Schenectady 5, N. Y. C

Circle 693 on Page 19

Door Interlock Switch

Applications for the 17AC1-T subminiature door interlock switch, described in Data Sheet 159, include high voltage and electronic equipment cabinets. It cuts off power when service door is opened. 2 pages. Minneapolis-Honeywell Regulator Co., Micro Switch Div., Freeport, Ill. K

Circle 694 on Page 19

High Strength Bolts

Complete performance and other data on EWB 26 aircraft bolts rated at 260,000 to 290,000 psi tensile strength are provided in Form 2527. Forged from high strength alloy steel, bolts have threads rolled after heat treatment. 4 pages. Standard Pressed Steel Co., Jenkintown, Pa. C

Circle 695 on Page 19

Servo System

Servo breadboarding system that requires only a rough schematic for complete production in a fraction of the usual time is described in technical Catalog 2. It shows completed unit with the steps and components used. 12 pages. Gap Instrument Corp., 116 Merrick Rd., Freeport, L. I., N. Y. D

Circle 696 on Page 19

Strain Gage

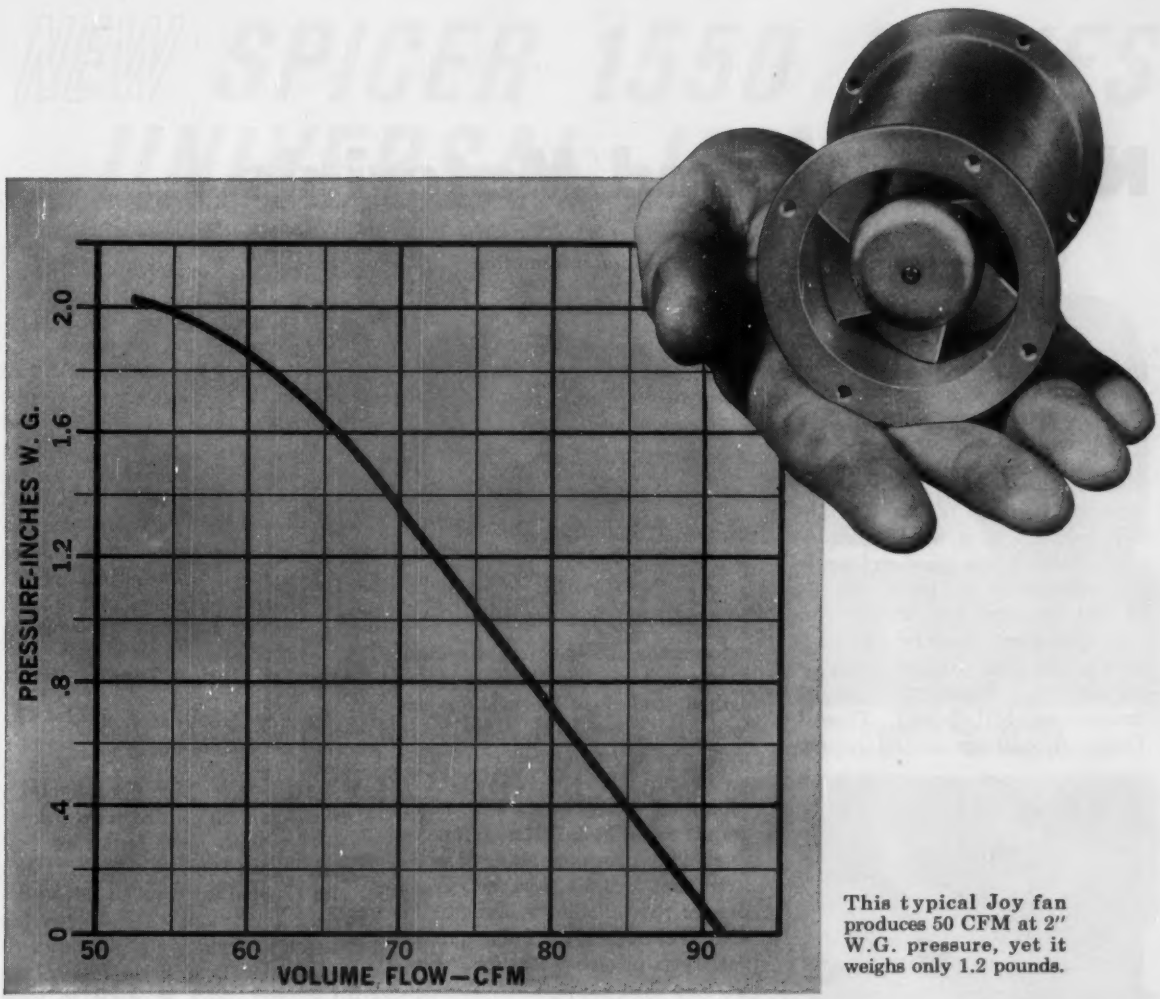
Report on the HTM Mono-Filament strain gage covers construction, areas of use, temperature range, installation procedure, special service, and configurations. Gages are made in four configurations, in 60, 120, and 240-ohm resistances. Spec and price list is included. 12 pages. High Temperature Instruments Corp., Bala-Cynwyd, Pa. E

Circle 697 on Page 19

Medium Power Transistors

Data Sheets J272 and J273 provide tentative specifications and typical characteristics of Type 2N696 and 2N697 NPN double-diffused silicon mesatransistors. Rated 2 w at 25° C case temperature, units have respective beta ranges of 20 to 60 and 40 to 120. 2 pages each. Texas Instruments, Inc., Semiconductor-Components Div., 13500 N. Central Expressway, Dallas, Tex. P

Circle 698 on Page 19



This typical Joy fan produces 50 CFM at 2" W.G. pressure, yet it weighs only 1.2 pounds.

➡ *Joy Design Means:*

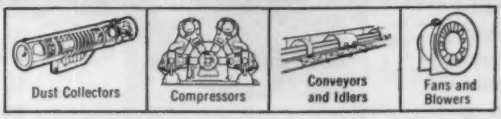
HIGHEST OUTPUT PER POUND OF FAN

Joy aircraft and electric fans are designed to provide maximum CFM per pound of fan. The inherent high efficiency of the basic vaneaxial design, with the motor mounted inside the fan, has made Joy fans standard wherever weight or size is a critical consideration.

Joy fans meet Mil Specs, and have been accepted for both airborne and ground installations. RCA, Boeing, Douglas, Goodyear, Motorola, Lockheed, and Raytheon are just a few of the firms incorporating Joy fans in their products.

Over 340 standard models are available, and custom design can be supplied to meet your special requirements. For complete information on how compact, efficient Joy fans can solve your design problems, write for Bulletin 927-64B.

AIR MOVING EQUIPMENT FOR ALL INDUSTRY



JOY

Joy Manufacturing Company
Oliver Building, Pittsburgh 22, Pa.

In Canada: Joy Manufacturing Company (Canada) Limited, Galt, Ontario

Circle 500 on Page 19

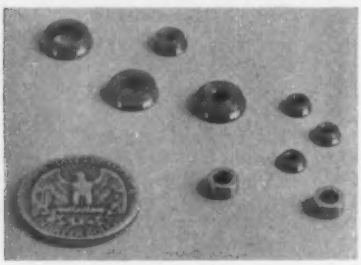
New Parts and Materials

Use Yellow Card, page 19, to obtain more information

Instrument Bearings

miniature bronze units are self-lubricating

Microspin precision miniature instrument bearings replace precision ball bearings in a wide variety of applications where speed and torque requirements do not justify the cost of ball bearings, but where precision instrument standards of tolerances, life, and friction must be maintained. Made of sintered bronze per MIL-B-5687, Type I, Comp. A, bearings are oil impregnated and completely self-lubricating. Available in a full range of standard miniature sizes, in both flanged and nonflanged styles, they are dimensionally interchangeable with standard miniature ball bearings. Tolerances can be specified equivalent to Class ABEC 5 or 7. **Northfield Precision Instrument Corp.**, 4400 Austin Blvd., Island Park, L. I., N. Y. D

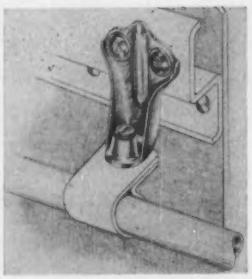


Circle 699 on Page 19

Bracket Nut

for wire conduit line supports

LHA71 one - piece, self - locking, right-angle bracket nut is for use in attaching wire bundles and plumbing lines to missile and airframe structures. Extrarigid nut has high resistance to twisting and distortion, minimizing maintenance and damage caused by deflection or



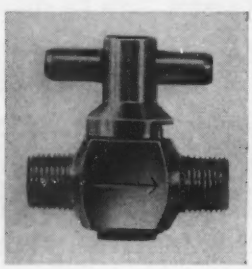
deformation under severe operating stresses. Made of cadmium-plated carbon steel, heat treated, for performance at temperatures to 550 F, nut exceeds performance requirements of MIL - N - 25027(ASG). Mounting holes of 0.13-in. diam permit use of 1/8-in. aluminum-alloy rivets to develop full bracket strength. No. 10-32 thread size is presently available in lengths of 0.45, 0.65, and 0.85 in. to provide variations in clamp location. **Elastic Stop Nut Corp.**, 2330 Vauxhall Rd., Union, N. J. D

Circle 700 on Page 19

Miniature Valve

leakproof unit is for vacuum or pressure service

Miniature leakproof shutoff valve, No. 9500, is designed for use in vacuum or pressure service. It features an O-ring on cylindrical face of straight plug which prevents leakage past inlet port as well as critical stem area. Glance at T-handle position instantly indicates exact valve position. Handle is color-coded for gas or liquid service, such as oxygen, air, nitrogen, hydraulic fluids, water, or oil. Repair can be made quickly without removing valve from line. Valve is available in brass or No. 303 stainless steel with either male or female connections in 1/8 or 1/4-in. size. **Circle Seal Products Co. Inc.**, 2181 E. Foothill Blvd., Pasadena, Calif. L



Circle 701 on Page 19

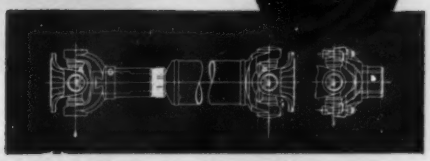
Asbestos Gasket Tape

fits around bolts or studs to form double seal

Asbestos gasket tape is available in three types: Plain wire inserted folded tape with open lattice or bolt space in the center, Style 746; plain wire inserted tape woven flat to desired dimensions and bolt-space openings, Style 738; plain woven nonmetallic tape, Style 748. Units fit around bolts or studs to form an efficient double seal, eliminating need to make two separate gasket applications on either side of bolts

or studs, or to perforate broad gasketing before use. Lattice width or bolt space of Style 746 is available from 1/8 to 7/8 in. Tape is furnished in over-all width from 1/2 to 3 in. and in thicknesses from 1/8 to 1/4 in. Style 738 is available in thicknesses from 1/32 to 3/16 in., and also is furnished to 8 in. width in 1/16-in. thickness. For 1/8, 1/4, and 3/16-in. thicknesses, maximum width is 6 in. Bolt space available is from 1/8 through 1 in. Style 748 is nonmetallic, manufactured like Style

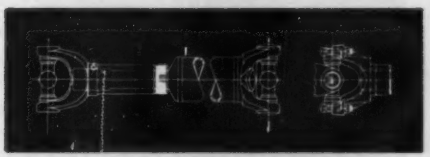
NEW SPICER 1550 SERIES UNIVERSAL JOINTS...



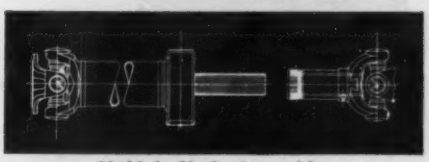
Standard Assembly
Flange Yokes or End Yokes are Optional

A bigger, more rugged universal joint for trucks with 29,000-30,000 GVW

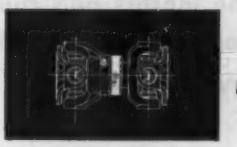
Spicer is now manufacturing a completely new series of universal joint . . . the 1550 series. With 20% greater bearing factor and a minimum elastic limit 20% greater than previous 1500 series joints, the 1550 series is a bigger performance value . . . *at lower cost.*



High Angle—Inter Axle Assembly
End Yokes are Standard



Multiple Shaft Assembly With Center Bearing



Short Coupled Assembly
Flange Yokes or End Yokes are Optional

The new 1550 series universal joints give you **these important performance advantages:**

- Reverse Spline Center Bearing construction.
- Crowned Bearing Races, for better bearing alignment, longer life.
- "U" bolt and snap ring design for reduced maintenance costs.
- Synthetic double lip type seal, for tighter, more positive sealing.
- Shorter length flange face to flange face on short coupled sets, to take full advantage of available space.
- Extremely close limits of static and dynamic balance for vibration-free operation.

The 1550 series is now available in all present variations of the 1500 series—including short coupled, high angle and long slip propeller shafts.

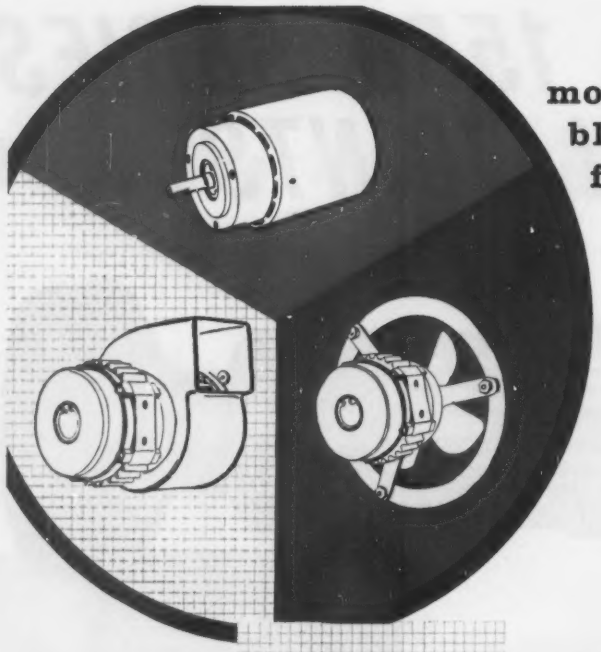
For more complete details on the new 1550 series universal joints write to Dana Corporation, Toledo 1, Ohio.

DANA Spicer

DANA CORPORATION
Toledo 1, Ohio

SERVING TRANSPORTATION—Transmissions • Auxiliaries • Universal Joints • Clutches • Propeller Shafts • Power Take-Offs • Torque Converters • Axles • Powr-Lok Differentials • Gear Boxes • Forgings • Stampings • Frames • Railway Drives.

Many of these products are manufactured in Canada by Hayes Steel Products Limited, Merritton, Ontario



motors
blowers
fans

BLOWERS

C F M	to 750 max.
Types	Single, double, inverted
Housings	2¼" to 11½", vertical, overall
Mountings	Flange, foot, cone

FANS

C F M	to 1000 max
Types	Axial, vane axial, ALTIMATIC ®
Blades	2" to 12"
Mountings	Venturi, foot

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738, with the same widths and thicknesses. All styles are furnished either plain or graphite coated on one side or both. **Fibrous Products Div., Union Asbestos & Rubber Co.**, 1111 W. Perry St., Bloomington, Ill. I

Circle 702 on Page 19

Subminiature Switch

for pressures to 200 psi

Subminiature, adjustable pressure switch has a volume of less than 1 cu in. and weighs only slightly over 1 oz. Unit exceeds requirements of MIL-E-005272B for performance to 200 psi under vibration, shock, and acceleration test condi-

tions. For electrical switching in response to pressure changes in gas or liquid, switch is particularly suited to applications in which high performance with minimum size, weight, and cost is important. **Bristol Co.**, Waterbury 20, Conn. B

Circle 703 on Page 19

Adjustable-Speed Drives

in ratings from 5 to 100 hp

Kinatrol eddy-current-coupling adjustable-speed drives feature simplified design with few moving parts. They are available for a broad range of general-purpose industrial applications. Drive is furnished as a complete package including drive unit, control enclosure, and operator's station. Versatile performance is offered over a wide speed range, with ratings from 5 to 100 hp. Ratings through 20 hp operate continuously down to 100 rpm at rated torque, providing speed range of about 17:1. Automatic control provides close speed regulation as standard. Ratings are in horsepower delivered at output shaft of coupling, rather than at output

NEW TENZ-NUT®

preassembled for fast production . . .

Now — a spring washer preassembled on a hex nut — to save time in all types of assembly operations where the tested principle of bolt, nut and spring washer are required. Developed by Eaton-Reliance, this new fastener is now available for production use.

The spring washer — a modified Belleville, or "cupped" type — is firmly attached to the hex nut, yet it spins freely during application and removal. Tenz-Nuts are reusable.

The proven locking principle of the cupped-type washer, when combined with a hex nut, gives you a versatile fastener for automatic assembly operations. It is particularly applicable where finished parts are being assembled and it is desirable to minimize surface marring. Tenz-Nuts may also be adapted as sealing nuts.

Write for our new Engineering Bulletin which fully describes Tenz-Nuts.

Eaton also offers a complete line of Keps®— hex nuts preassembled with tooth-type washers. Our fastener engineers will gladly consult with you on possible applications on request.

EATON

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His name is STANPAT, and though he is not human he can swallow up your tedious re-drawing and re-lettering of standard and repetitive blueprint items for 24 hours a day if need be—without tiring. STANPAT is the remarkable tri-acetate sheet that is pre-printed with your specification and revision boxes, standard symbols, sub-assemblies, components and cross-sections . . . with adhesive front or back, waiting to be pressed into position in 15 seconds! Reproductions are unusually crisp and clear, guaranteed not to wrinkle, dry out or come off. STANPAT saves hundreds of hours in drafting time and money, allowing the engineer more time for creative work.

Already employed in numerous firms, STANPAT can go to work for you, too! Send us your drawing details now for quotation and free sample, no obligation.

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☐ Kindly send me STANPAT literature and samples.

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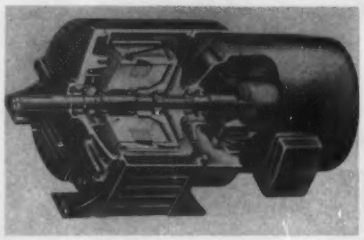
Company_____

Address_____

Circle 506 on Page 19



shaft of ac motor. Coupling design features include new bearing arrangement and reduced bearing loads. Coupling field coil and tachometer generator are stationary, with no brushes or slip rings. Control enclosure elements are all front wired. **Direct Current Motor & Generator Dept., General Electric Co., Erie, Pa.** F

Circle 704 on Page 19

Nylon Pressure Tubing

for high-pressure fluid and pneumatic service

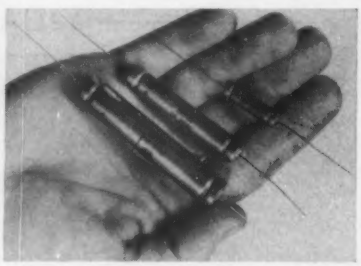
Nylon pressure tubing in a wide variety of diameters and wall thicknesses is offered for high-pressure fluid and pneumatic service, and in push-pull applications where friction is a problem and lubrication impossible or impractical. Continuous lengths are furnished from minimum size of 0.01 x 0.06 in. to a maximum of 0.28 x 0.5 in. Applications include flexible-cable casing, heater and vent control cable casing, wire cladding, and fluid conductors. **Garlock Packing Co.,** 440 Main St., Palmyra, N. Y. E

Circle 705 on Page 19

Tantalum Capacitor

is 300-v, foil-type unit

Tantalytic tantalum electrolytic capacitor is designed primarily for applications in missiles, computers, and airborne electronic equipment where minimum size and weight



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LISLE *Magnetic* **PLUGS**

If your product has moving parts operating in a fluid, you can reduce costly wear with Lisle Magnetic Plugs.

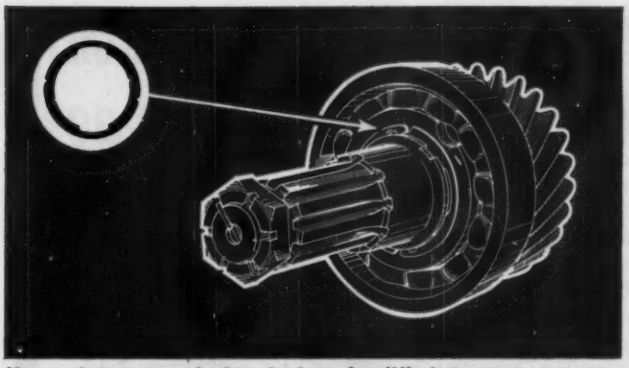
Ferrous metal particles in a lubricant are a major cause of wear. The Lisle Magnetic Plug removes these particles from the lubricant — assures longer, quieter operation of the products you make.

Lisle Magnetic Plugs can be used in place of any ordinary drain or fill plug.

FREE Samples for Testing in Your Product!

LISLE CORPORATION
Clarinda, Iowa

Circle 507 on Page 19



Heavy duty transmission design simplified. On this dual axle drive for trucks, a Truarc Series 5107 ring locks bearing on drive shaft. Interlocking ring design won't dislodge under heavy torque . . . is also recommended for high rpm. applications.

Designing with radially assembled Waldes Truarc retaining rings

solve varied product design problems—save machining, materials, parts and labor

Radially assembled retaining rings, which snap onto a shaft at right angles to its axis, greatly extend the range of products on which retaining rings may be used to simplify design and save parts or labor costs.

For example, rings for radial assembly can be used in applications where it is impossible to install a ring axially over the end of a shaft. Certain types are designed to accommodate shafts of relatively wide tolerances. Others described below may be used to provide a sizeable shoulder on a shaft.

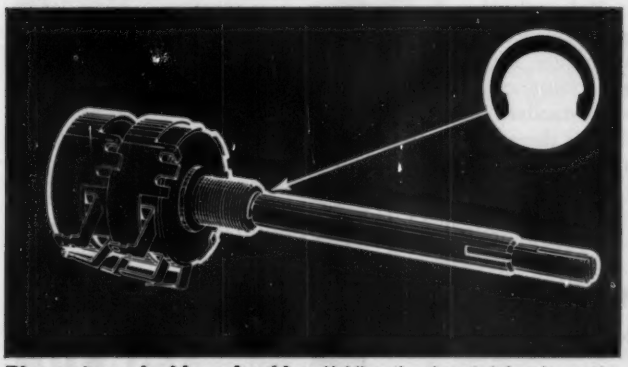
The four applications shown here provide an indication of the wide range of products using radially assembled rings. The rings themselves are basic Truarc types each having specific design features. The high shoulder of one provides a large bearing surface on small diameter shafts; the low shoulder of another is ideal where clearance is limited. A third has an interlocking design which prevents it from being dislodged under torque or high rpm. A fourth can be used against rotating parts at the same time it provides spring tension.

These are but four of Truarc's fifty functionally different types of retaining rings with up to 97 sizes within a single type, six metal specifications and thirteen different finishes. Special hand, magazine, and semi-automatic applicators as well as grooving tools are also available to speed production. The entire line, together with over 70 typical applications, is described and illustrated in the new catalog RR10-58—yours for the asking. And call on us for design assistance on your specific project . . . a Waldes Truarc engineer will be glad to help. Waldes Kohinoor, Inc., 47-16 Austel Place, Long Island City 1, N. Y.

©1959 WALDES KOHINOOR, INC. 9.9

Rings replace machined shoulders, collars, set screws. That's what original design of this pneumatic temperature transmitter called for. Series 5139 Prong-Lock® ring with bowed design compensates for accumulated tolerances in parts, provides sufficient friction to prevent rotation under vibration. At the same time two Waldes E-rings position and lock adjustment screw to face plate.

Reinforced aluminum ring gives design advantages on louver windows. Waldes Truarc Series 5144 reinforced rings of aluminum secure hinge pins, eliminate costly riveting in linkage of louver type window. Ring design provides large bearing shoulder. Reinforced construction has 5 times the gripping strength of standard E-ring construction, allows use of non-corrosive aluminum.



Ring acts as locking shoulder. Holding the threaded ferrule on this potentiometer shaft is a Truarc Series 5103 Crescent® ring. Crescent ring design with low shoulder provides ample clearance for assembly of panel locknut. It is less costly than a machined shoulder, more effective, quicker to install, easier to remove than the C washer previously used.

WALDES TRUARC® RETAINING RINGS

Waldes Kohinoor Inc., Long Island City 1, N. Y.

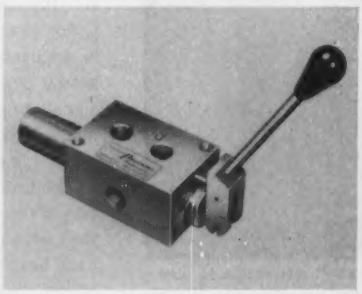
TRUARC RETAINING RINGS...THE ENGINEERED FASTENING METHOD FOR REDUCING MATERIAL, MACHINING AND ASSEMBLY COSTS

are major considerations. The 300-v, foil-type unit is available for operation at 85 C to 300 v and 125 C to 250 v. Capacitance change of no more than 10 per cent is specified after 2000 hr operation at rated voltage and temperature. At −55 C, maximum capacitance change is 20 per cent. Capacitance tolerances are ±15 per cent. Available in seven case sizes in both polar and nonpolar construction, capacitor is supplied in tubular styles with lightweight aluminum casing, insulation tubing, and axial leads. **General Electric Co.**, Schenectady 5, N. Y. C

Circle 706 on Page 19

Directional-Control Valve

for use in small hydraulic circuits



Miniature, four-way directional-control valve with sliding-spool construction is only 2 x 1½ x 5 in. in size and weighs 1 lb 2 oz. Designed especially for use in small hydraulic circuits (under 3 gpm), valve has a pressure drop of approximately 13 psi at rated capacity of 3 gpm. Valve also has low internal leakage. Balanced spool is hard-coated aluminum which provides high wear resistance. Valve is available with standard ⅛ and ¼-in. dry-seal pipe threads. **Sarasota Precision Products Inc.**, 5757 McIntosh Rd., Route 1, Sarasota, Fla. O

Circle 707 on Page 19

Flexible Coupling

for shafts to 5½ in. diam

Model GH flexible coupling is for heavy-duty use in sizes from 35 to 700 hp at 1800 rpm and for shafts to 5½ in. diam. It consists of two metal bodies with interlocking jaws separated by nonmetallic load cush-

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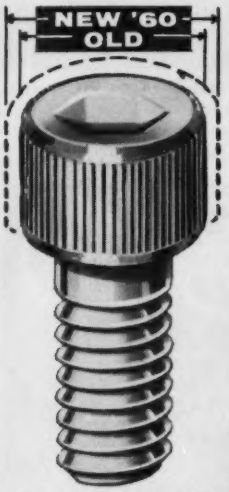
Circle 509 on Page 19

MORE HOLDING POWER

with SETKO'S '60* SERIES socket cap screws



- Bigger heads take greater tightening torques without indenting.
- Broader bearing area under head distributes load over larger area.
- Better strength characteristics assure longer life—can be re-applied more times.
- Stainless Steel Cold Forged Cap Screws now available in many sizes.

Now you can get Setko's "perfect-hole" precision in the new '60 Series. All of the outstanding qualities of precision-made Cold Forged Cap Screws are combined in this new, larger-head size series, to give you increased holding power, and longer, more dependable performance.

In some cases you actually need fewer Cap Screws because of the increased holding power. The broader bearing area under the head stops needless indenting of material — and often eliminates the need for washers. With the Setko '60 Series Socket Cap Screws you can cut costs, increase reliability and step up performance.

WRITE FOR FULL INFORMATION on Setko's '60 Series. Cold Forged, Socket Cap Screws. Tell us your requirements for recommendation and quotations.

*Old series will continue to be available

SETKO

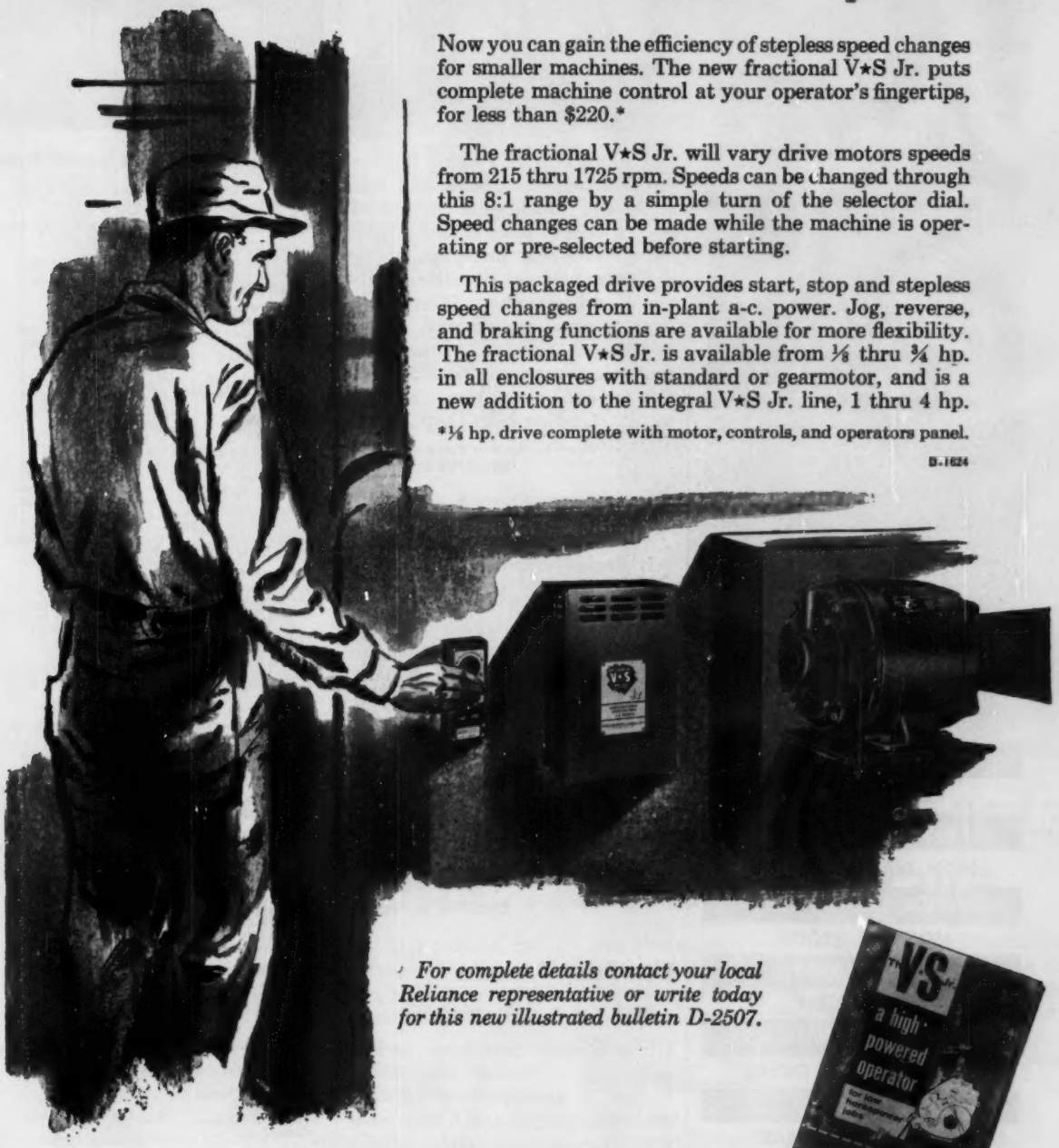
Set Screw & Mfg. Co.

725

28 Main Street, Bartlett, Illinois

Circle 510 on Page 19

INTRODUCING AN ALL ELECTRIC, VARIABLE SPEED DRIVE FOR UNDER $220.* THE FRACTIONAL hp. V★S Jr.



Now you can gain the efficiency of stepless speed changes for smaller machines. The new fractional V★S Jr. puts complete machine control at your operator's fingertips, for less than $220.*

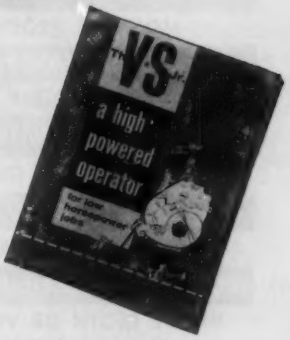
The fractional V★S Jr. will vary drive motors speeds from 215 thru 1725 rpm. Speeds can be changed through this 8:1 range by a simple turn of the selector dial. Speed changes can be made while the machine is operating or pre-selected before starting.

This packaged drive provides start, stop and stepless speed changes from in-plant a-c. power. Jog, reverse, and braking functions are available for more flexibility. The fractional V★S Jr. is available from ⅛ thru ¾ hp. in all enclosures with standard or gearmotor, and is a new addition to the integral V★S Jr. line, 1 thru 4 hp.

*⅛ hp. drive complete with motor, controls, and operators panel.

D-1624

For complete details contact your local Reliance representative or write today for this new illustrated bulletin D-2507.



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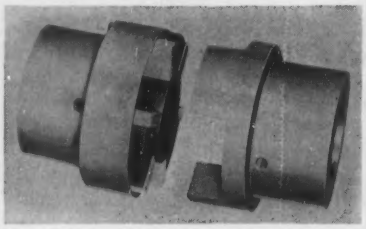


ions which provide a spring cushion for vibration, shock loads, and misalignment. Removable individual inserts, held in place by a steel collar, provide easy inspection or replacement without disturbing driving or driven units. There is no metal-to-metal contact and no lubrication is required. Inserts are available to meet all operating conditions and government requirements. **Gerbing Mfg. Corp.**, South State Road, Elgin, Ill. J

Circle 708 on Page 19

Epoxy Insulating Compound

is single-component type

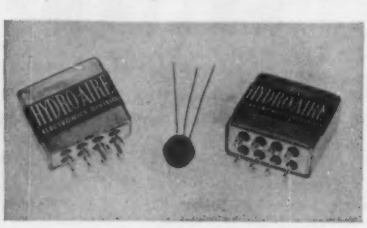
Thermopoxy U-854 single-component epoxy insulating compound is available for simultaneous encapsulation and impregnation of stator end windings and slots by vacuum-dip process. The thixotropic compound eliminates need for molding stator end windings and slots. Use of material results in lower production costs, simplified handling, and cooler operations. **Sterling Varnish Co.**, Haysville Borough, Sewickley, Pa. E

Circle 709 on Page 19

Time-Delay Devices

in 1 x 1 x ½-in. enclosure

Ultraminiature time-delay devices, employing minimum components, include a time-delay relay, static time-delay switch, and timing module. They provide simple, reliable design in an enclosure only 1 x 1 x ½-in. in size. All units operate at 24 to 31 v dc, or from 18 to 50 v



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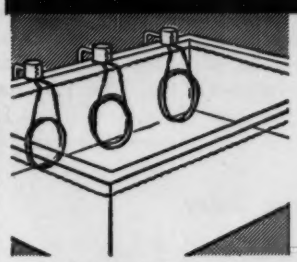
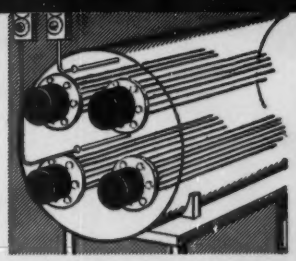
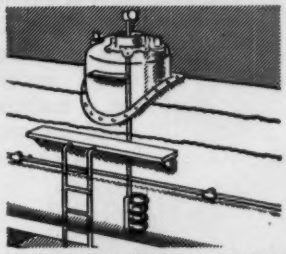
Call your CHROMALOX Man for heating answers



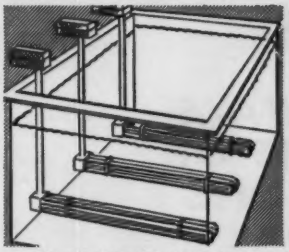
For plating applications, Chromalox CT Immersion Heaters are sheathed in lead, copper, stainless steel.



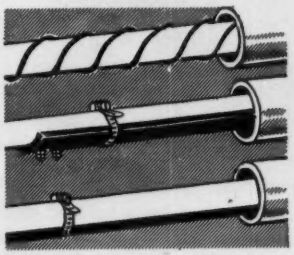
Water heating with TM flange-type Immersion Heaters mounted at one end of a tank.



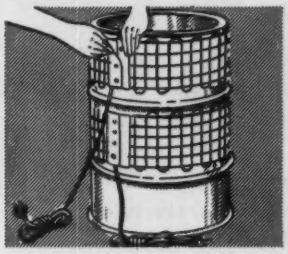
Heating viscous materials with BLCK Immersion Heaters before pumping from a railroad tank car.



Heating liquid held at constant level. TL Heaters generate heat parallel to the tank bottom.



Pipe heating with Chromalox Thermwire (300°F), Strip Heater (750°F) and Tubular Heater (1100°F).



Heat for 5- and 55-gallon drums. Just snap on and plug in. Protective coating resists abrasion, chemicals.

LIQUIDS? Only CHROMALOX heats so many things . . . so many ways

There's one best way to do any job. And you get the best results only by using that one best method.

Regardless of what your heating problems may be . . . your best chance of finding the best answer is to call your Chromalox Man.

- He represents more than 15,000 different types, sizes and ratings of electric heaters and heating elements . . . the world's largest line.
- He orders from the world's largest stock.
- And he is a *heating expert* . . . he understands your problem and can help you find the answer.

Maybe Chromalox Strip Heaters are the answer. They quickly and easily bolt or clamp to platens, dies, kettles, tanks, pipes, rolls, drums, ovens, air ducts. Or maybe Chromalox Tubular Heaters. They clamp on, fit into machined grooves, cast into metals, immerse in liquids, install in ovens and ducts. Chromalox Cartridge Heaters smoothly fit standard drilled holes in dies, platens, molds, extrusion and injection barrels. Many other types of Chromalox heaters do many other jobs.

No matter what your heating problem is . . . solids, liquids or gases . . . call your Chromalox Man for the efficient, *electrical* answer. (*His name and phone number are listed at the left.*) Or, check the boxes below, write your name, title, and address at the bottom of this page and mail it to us. Edwin L. Wiegand Company, 7500 Thomas Boulevard, Pittsburgh 8, Pa.

☐ Send me Catalog 60
(General Industrial heating applications).

☐ Send me specific information on the heating problems I have outlined on the sheet attached.

☐ Have a Chromalox Representative contact me.

☐ Do not have a Chromalox Representative contact me.

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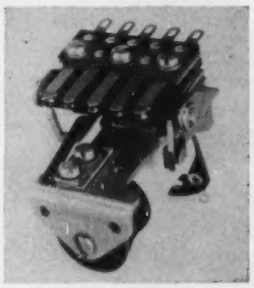
by special design. They are hermetically sealed and finished in a nickel-silver alloy can. **Electronics Div., Hydro-Aire Co.**, 3000 Winona Ave., Burbank, Calif. L

Circle 710 on Page 19

Program Relay

provides variety of switching combinations

Series 1450 program relay is a compact unit which provides a wide variety of cam-operated switching combinations. Cams and ratchet wheel are molded from a material which provides unlimited life and quiet operation, and cams of any



configuration can be supplied. They are pressed on a splined shaft so that any desired orientation can be obtained. Dc or ac coils can be provided for any voltage to 200 v. Contacts for dry circuit or 7½ amp are available. Standard arrangement is 12 position, 5 pole, but other arrangements are also available. Unit is supplied open, sealed, or with dust cover. Size is 1 9/16 x 1¾ x 2 in. long, and weight is 4½ oz. **Standard Electromagnetics Inc.**, Walkersville, Md. C

Circle 711 on Page 19

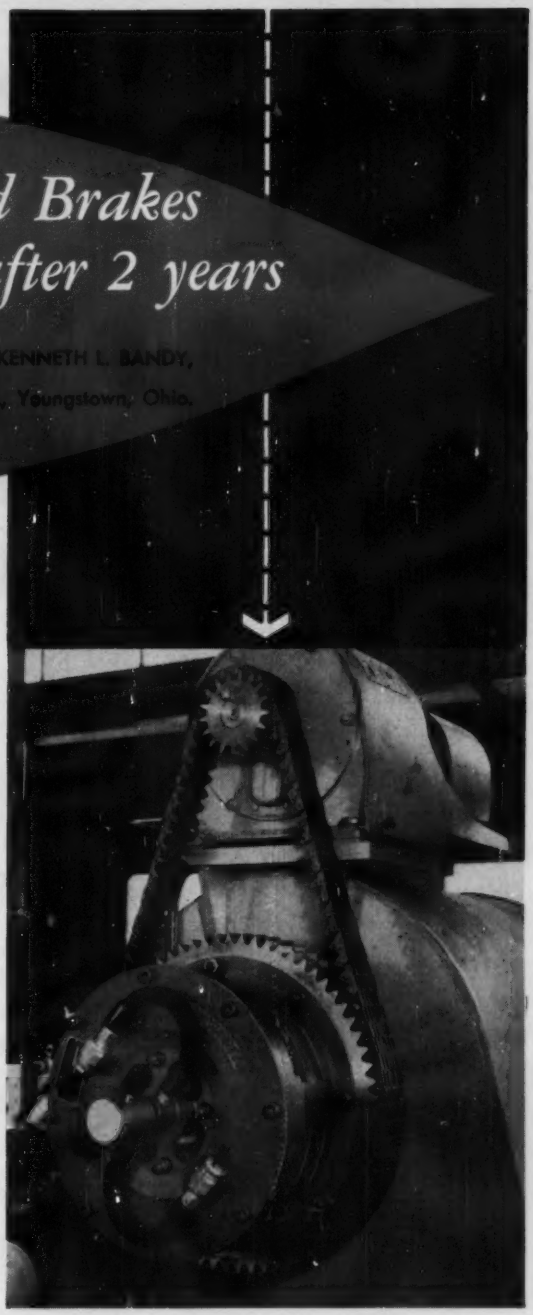
Laminated Plastics

for use in temperatures to 500 F

Two high-temperature industrial laminated plastics are ARF-HT, an asbestos-mat plastic, and G3-HT, a glass-fabric material. Grade ARF-HT consists of an asbestos-mat reinforcement with a modified phenolic resin binder for temperature resistance to 500 F. It is available in sheets and strips, and in tube form for special requirements. Flexural strength is 35,000 psi lengthwise and 25,000 crosswise. Tensile

"Wichita Clutches and Brakes using original linings after 2 years continuous service,"

says KENNETH L. BANDY,
Chief Development Engineer, THE McKAY MACHINE CO., Youngstown, Ohio.



"Two years ago, we developed our automatic strip feeding line for progressive-die presses. We specified Wichita clutches and brakes for this equipment because of the rapid and smooth engagement of the clutches and the extremely low inertia of the brakes.

Recent inspection of these Wichita units showed that after two years of continuous service not a single part needed replacing. No evidence of heating has ever been detected."

For top performance from your equipment, it will pay to investigate Wichita for improved clutching and braking. A Wichita Engineer will gladly discuss your special requirements at your convenience. He is available immediately.

Wichita ATD-LI Clutch (above) and Brake (upper left) shown on McKay Strip Feeding Equipment . . . providing outstanding service.

Contact Your Nearest Wichita Engineer!

Clutch & Control Engineering Co., Livonia, Mich.
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Allied Transmission Equipment Co., Kansas City 8, Missouri
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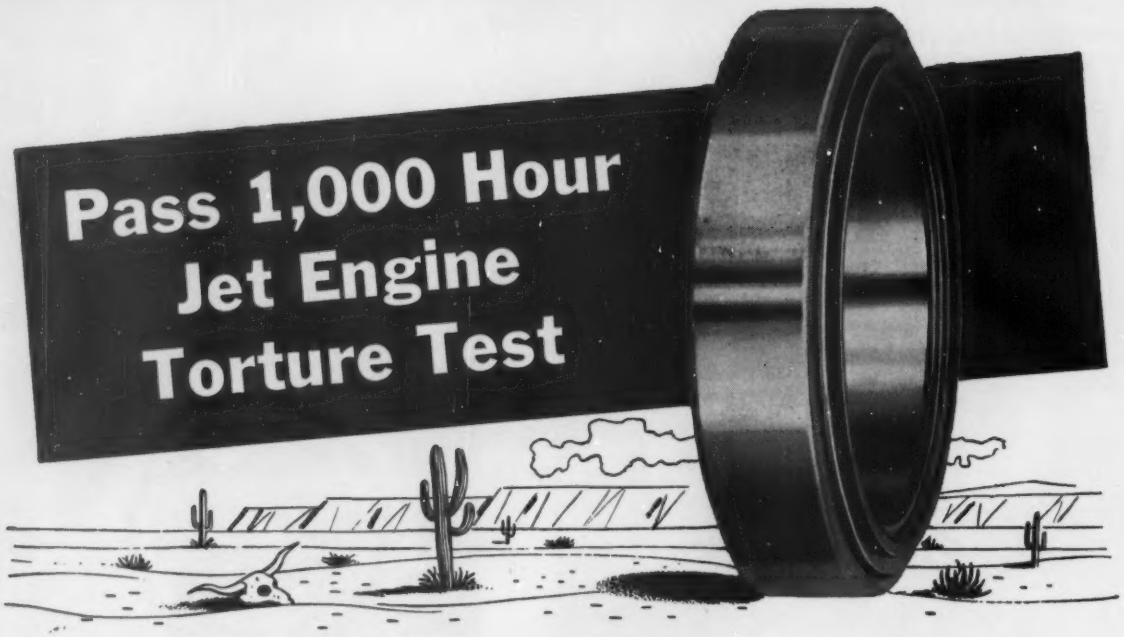
Norman Rupp Co., Portland 4, Ore.
Bates Sales Co., St. Louis 1, Mo.

WICHITA Clutch COMPANY, INC.
WICHITA FALLS, TEXAS, U.S.A.

Circle 515 on Page 19

SEALOL MECHANICAL SEALS



Conditions: 7,000 RPM 250°F. 0-250 PSI cycling pressures

Results: *NO SIGNS OF WEAR – ZERO LEAKAGE*

Picture a ¾" jet engine pump shaft running bone dry at 7,000 RPM, temperatures to 250°F. . . . hour after hour. Suddenly, water surges into the pump, slams into the shaft seal with momentary pressures running to 650 PSI. For 2 minutes, water is pumped at 250 PSI, then back to 4 hours of dry running.

After one thousand hours of continuous service, the seals showed no signs of wear . . . zero leakage during the water cycle. The secret behind this outstanding performance record is in the special "one-thirteen" treatment given the carbon faces.

SEALOL — *the versatile seal*
CURRENT APPLICATIONS

RPM	Shaft Size	Temperature	Fluid	Pressure
51,000	13/16"	400°F	Peroxide steam and nitrogen	0-10PSI
17,000	3"	225°F	Air Oil Mist	2-3PSI
37,500	1"	650°F	Mil-O-5606	20-30PSI
13,800	1 11/16"	—300°F	LOX	50PSI
3,500	1⅜"	270°F	Acetone, H2S04 and Phenol	80PSI
1,750	1⅛"	100°F	Mercury with 5% water	160PSI
173	1"	210°F	Tomato products	30PSI
25	1¼"	Ambient	Heavy Water	150PSI

YOUR PARTICULAR SEALING PROBLEMS . . . may or may not call for "one thirteen" treated seals . . . or welded metal bellows seals . . . or heavy duty Flexibox-type seals . . . or low cost RS seals.

The important point is that you can look for longer life, lower costs and better performance when you contact your nearest Sealol Engineer for detailed information and recommendations.

Write for further information or . . .

SEALOL CORP.

341 Post Road, Providence 5, R. I.

CALL your nearest Sealol engineer now.

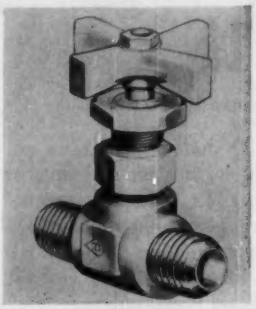
Providence — Stuart 1-4700
New York — Whitehall 3-9748
Phil. — Tremont 2-2226
Chicago — Independence 3-6707
Cleveland — Washington 1-7234
Dayton — Axminster 8-3009
Houston — Greenwood 2-2318
Los Angeles — Chapman 5-3746

strength is 20,000 psi lengthwise and 12,000 psi crosswise. Grade G3-HT has glass-fabric reinforcement and modified phenolic resin binder for temperatures to 500 F. Properties include flexural strength before exposure of 60,000 psi lengthwise and 50,000 psi crosswise. Tensile strength is 30,000 psi lengthwise and 25,000 crosswise. Material is also furnished in sheets and strips, with tubes available for special requirements. **Synthane Corp.**, Oaks, Pa. E

Circle 712 on Page 19

Needle Valves

miniature units are for pressures to 3000 psi



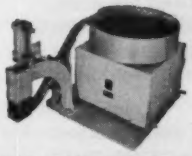
Small-line circuitry, including instrumentation, gage cut-off, test panels, and manifolds can use new valves to advantage for pressures to 3000 psi. Miniature needle units, designated Instru-needle, have a variety of port-threading combinations which enable direct connections to save space, fittings, and installation and maintenance costs. Both inline and angle designs are available in brass and stainless steel, either regular or for panel mounting. Sizes $\frac{1}{8}$ and $\frac{1}{4}$ in. internal and external pipe, and $\frac{1}{4}$ and $\frac{3}{8}$ in. OD flared and flareless tube threadings are standard. Temperature ranges from −65 to +450 F. **Republic Mfg. Co.**, 15655 Brookpark Rd., Cleveland 35, Ohio. G

Circle 713 on Page 19

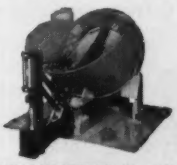
Speed Reducers

miniature units have ratios from 9:1 to 3000:1

Quarter-size miniature speed reducers, Type U1, are approximately 15/16 in. in diam and have size



VIBRATORY FEEDER for light, fragile or highly finished parts.



ROTARY FEEDER for high production feeding.

ROTARY HIGH SHELL FEEDER for maximum holding capacity.

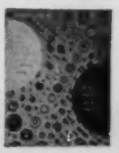
Shuffle and deal parts for automatic assembly with

DPS selective feeders

It takes fast, automatic feeding to satisfy the appetites of today's automatic assembly machines. And nowhere can you duplicate the range of equipment, the specialized experience in selective feeders offered by Detroit Power Screwdriver Company.

The most complete line in industry, DPS parts feeders include rotary, vibratory and elevator types. They handle any product from the tiniest of screws to assembly components the size of your fist . . . range in holding area from eighty cubic inches to 20 cubic feet.

DPS will welcome an invitation to analyze your assembly operations. If lagging production can be traced to inefficient feeding, the problem is as good as answered. Write for catalog on selective feeders.



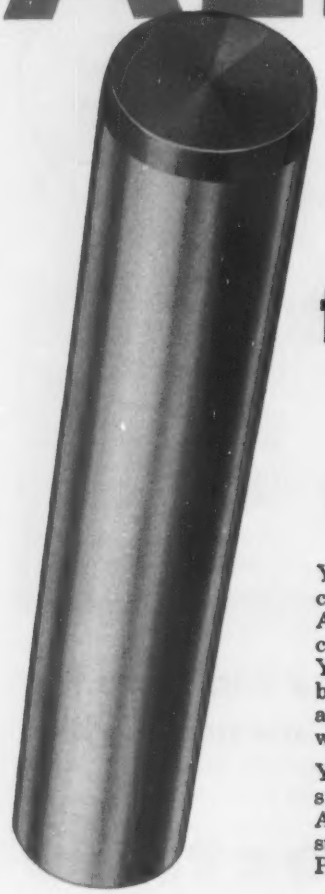
DETROIT POWER SCREWDRIVER COMPANY 15,038

2801 W. Fort St. • Detroit 16, Michigan

A Subsidiary of Link-Belt Company

Circle 517 on Page 19

ALLEN

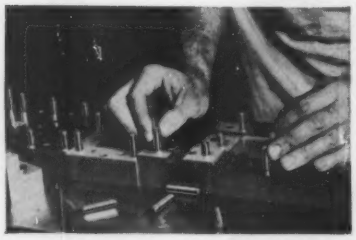


ALLEN is the dowel pin that gives you PLUSES!

Your ALLEN Industrial Distributor can show you a good many ways to use ALLEN Dowel Pins, in addition to conventional uses in tool and die work. You can use them as economical roller bearings, axles, precision plugs, hinge and wrist pins—and in many other ways.

You can cut the cost of your product substantially, too—because your ALLEN Distributor can supply these strong, accurate, mirror-finished Dowel Pins in standard sizes right from stock.

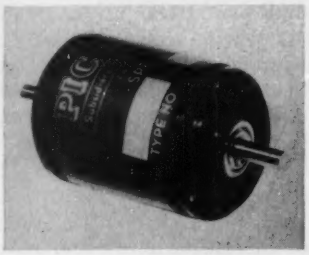
Made of special Allenoy steel; surface hardened to 62-64 Rockwell C; precision ground to .0001″ with micro-inch finish of 6 RMS max. Check your Allen Handbook or Catalog for detailed specs and standard sizes, or write direct for samples and technical information.



Genuine ALLEN products are available only through your ALLEN Distributor—he's always ready, willing and able to give you prompt, practical service.

ALLEN MANUFACTURING COMPANY
Hartford 1, Connecticut

ALLEN HEX-SOCKET SCREWS HEAD



10 frames. They are available in ratios from 9:1 to 3000:1. Units use precision ABEC No. 5 ball bearings throughout. Maximum rated output torque is 35 oz-in., and backlash through entire train is less than 30 min measured at output shaft. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, L. I., N. Y. D

Circle 714 on Page 19

Shaft Seal

for corrosive service

Type 20 shaft seal handles all concentrations of acids and salts, strong oxidizing or reducing agents, and all organic compounds. Bellows-type construction makes it well suited for many slurry applications and allows maximum seal axial flexibility to compensate for pump shaft runout. Seal is of Teflon construction in all areas that contact liquid or gas. It is available in two single-face types, one for internal and the other for external mounting. Double-face type is also available for internal mounting only. Shaft sizes range from 5/8 to 3 in. Seal size and operating temperatures determine maximum operating pressure. **Crane Packing Co.**, Dept. MD-1, 6400 Oakton St., Morton Grove, Ill. I

Circle 715 on Page 19

Pilot Light

subminiature unit is watertight on panel face

No. 101-8430W subminiature pilot light incorporates a flat, 1/32-in. thick, neoprene gasket on shank of lens holder and 1/16-in. thick retained O-ring seal behind flange of mounting bushing. Use of these seals provides a light which is watertight on face of panel. Light is 1 7/16 in. long and mounts in a single 15/32-in. clearance hole.

BARKSDALE AIR-SEAL* VALVES

LOW PRESSURE AIR TO 250 P.S.I.

. . . over 200 different valves available.

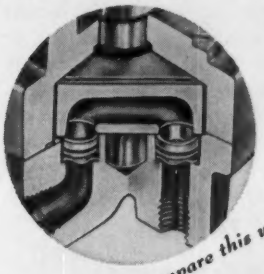
The air pressure is the sealing force . . . the higher the pressure, the tighter the seal.

Why so many different air valves?

Because air valve requirements vary with the method of actuation. A basic valve with interchangeable actuators cannot possibly meet ALL your specific applications without compromise. For example: A solenoid valve designed for speed would not have the stamina required of a manual or foot valve.

The Barksdale line of AIR-SEAL Valves has been designed with your requirements in mind. All our valves have been engineered for best performance from your point of view . . . for YOUR specific need, and not to make OUR job easier.

MANUAL and FOOT OPERATED "SHEAR-SEAL" VALVES



No oilers and filters needed — not critical to dirt and corrosion — made from non-corrosive materials.

Years of leakproof service — without constant maintenance — Self aligning "Shear-Seal" design compensates for normal wear.

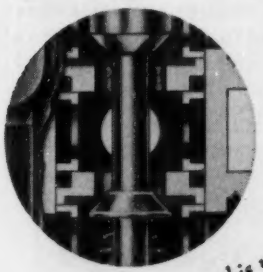
compare this with conventional

SPOOL or PLATE VALVES

Alignment is critical — dirt and corrosion cause sticking.

There is no compensation for normal wear — leakage increases with use.

SOLENOID-PILOT CRESCENT® (Self-aligning poppet) VALVES



Quick response (12 milliseconds) due to short travel of poppets and solenoid.

Tight sealing — self-aligning, self-scavenging design adjusts to normal wear — not critical to dirt and corrosion — non-corrosive materials throughout.

No coil burnout — heat dissipating "integral" design.

compare this with conventional

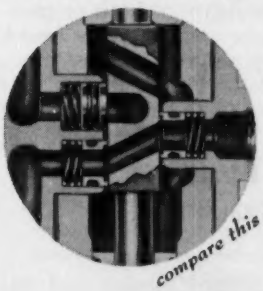
SPOOL VALVES

Slower response due to long spool travel.

Leakage increases with use — dirt and corrosion particles are ground-in between spool and seals—Sticking!

Overheating causes coil burnout — poor heat transfer of "unitized" design.

DIRECT-SOLENOID OPERATED "SHEAR-SEAL" VALVES



Leakproof for years of service — self-adjusting to wear.

No coil burnout — because valve does not freeze up.

compare this with conventional

SPOOL VALVES

Dirt enters spool clearances — develops leaks — causes sticking — sticky valves are to blame for most solenoid burnout.

Write for Air Valve Catalog 9-AV

CONTROL VALVE DIVISION

Barksdale valves

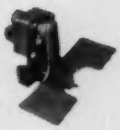
5125 ALCOA AVENUE • LOS ANGELES 58 • CALIFORNIA

MANUALLY OPERATED

4-Way valves 1/4 to 1 1/2" N.P.T. with or without spring return

Shut-off valves 1/4 to 1" N.P.T. with or without spring return

FOOT OPERATED



4-Way valves 1/4, 3/8 and 1/2" N.P.T. with or without spring return

SOLENOID-PILOT

4-Way valves 1/4 to 3/4" N.P.T. A.C. and D.C. Standard

Explosion-proof

J.I.C. type

With manual override

3-Way valves 1/4 to 3/4" N.P.T. A.C. and D.C. Standard

With manual override

Explosion-proof

DIRECT SOLENOID

4-Way valves 1/4, 3/8 and 1/2" N.P.T. A.C. and D.C. Standard

Explosion-proof

3-Way valves 1/4, 3/8 and 1/2" N.P.T. A.C. and D.C. Standard

Explosion-proof

Shut-off valves 1/4, 3/8 and 1/2" N.P.T. A.C. and D.C. Standard

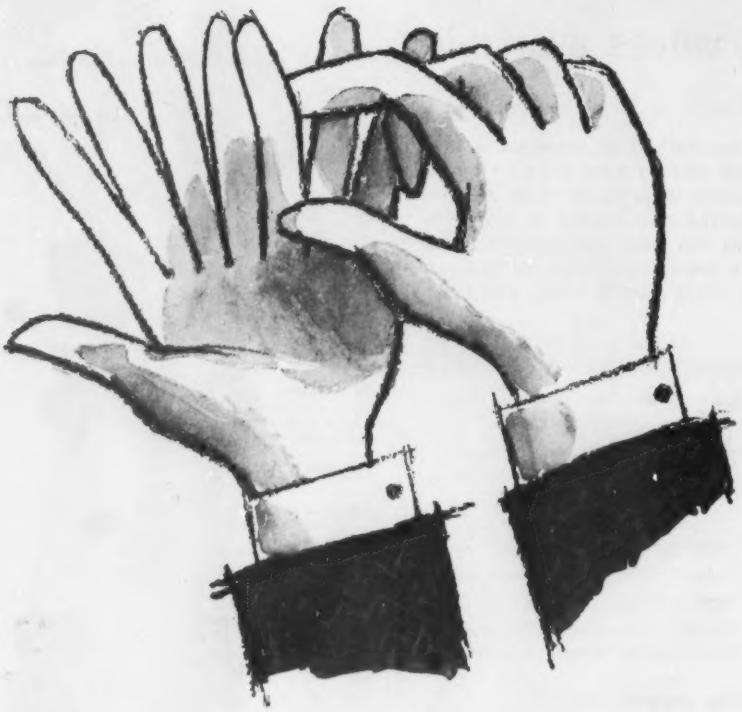
Explosion-proof

Diverter valves 1/4, 3/8 and 1/2" N.P.T. A.C. and D.C. Standard

Explosion-proof

Circle 519 on Page 19

Tired of counting the excess?



You save seven ways by using Wheelock-Lovejoy's *local* alloy steel warehouse facilities.

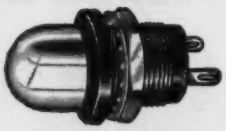
The usual costs of handling, cutting, storage, insurance, taxes, accounting, and—in some cases—obsolescence, are *all* eliminated when you order from your local Wheelock-Lovejoy Service Center. You can order your alloy steel—*as you need it*—in any size, shape or grade. See the listing below for the W-L Branch nearest you.

W-L STEEL SERVICE CENTERS—Cambridge
Cleveland • Chicago • Hillside, N. J.
Detroit • Buffalo • Cincinnati

AGENTS—Southern Engineering Company, Charlotte, N. C.; Sanderson-Newbould, Ltd., Montreal and Toronto

WHEELOCK, LOVEJOY & COMPANY, INC.
134 Sidney St., Cambridge 39, Mass.

AMERICAN STEEL WAREHOUSE ASS'N.



(Actual size)

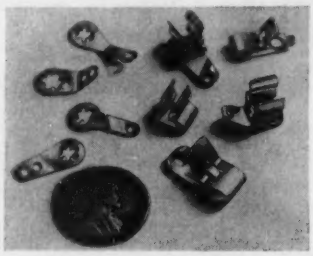
Mounting from front of panel facilitates replacement of either complete unit or lamp. Unit is fully insulated and requires no special insulating washers. Light accommodates T 1¾-in. midget-flange-base incandescent lamps of voltages from 1.3 to 28 v. Assembly meets all applicable military specifications. Stovepipe-shaped cap of high-heat plastic, available in transparent or translucent finish in clear or six colors, provides all-angle visibility. **Dialight Corp.**, 60 Stewart Ave., Brooklyn 37, N. Y. D

Circle 716 on Page 19

Clips and Terminals

are available from stock

A variety of spring and fuse clips and lock-washer terminals have been added to a line of electrical parts and are available from stock. Lock-washer terminals are manufactured with No. 4, No. 6, and No. 8



holes from 0.018 in. brass or phosphor bronze, hot tinned. **Zierick Mfg. Corp.**, 110 Beechwood Ave., New Rochelle, N. Y. D

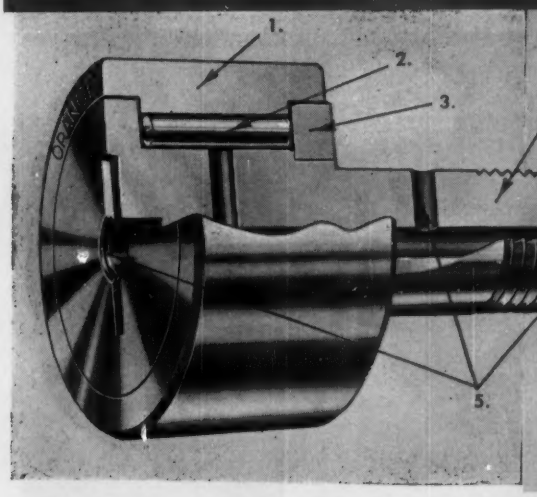
Circle 717 on Page 19

Silicone Varnish

cures in only 6 hr at 150 C

Class H silicone dipping and impregnating varnish, No. 980, meets AIEE requirements for use in 220-C systems, and has high heat stability. It resists moisture and is unaffected by many corrosive atmospheres. Material cures in only 6 hr at 150 C. It also has lower run-

HIGH LOAD CAPACITY– HIGH SHOCK RESISTANCE– FOR CAM APPLICATIONS



1. Heavy-sectioned outer race is made of thru-hardened, precision-ground, high quality bearing steel.

2. Small diameter rolls are made of high grade bearing steel, electronically gauged for uniformity of size.

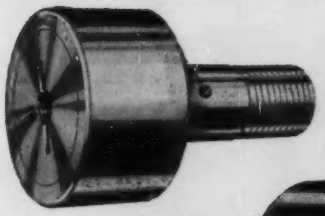
3. Case-hardened End Plate permits the use of effective press fit for retention.

4. Induction-hardened Stud assures maximum hardness of the roller track, with core toughness to withstand high shock loads. Slotted end for convenient screw driver mounting.

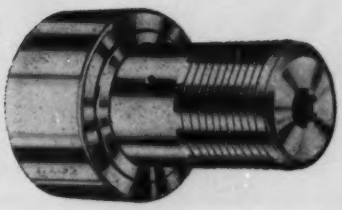
5. Selective Lubrication for design flexibility. Drilled for drive type fitting. Closing plugs also furnished.

ORANGE CAM FOLLOWERS

Every detail in the design and construction of Orange Cam Followers has been engineered to provide the maximum in precision, friction-free, durable service required by cam-activated mechanisms. Available in 22 standard sizes from ½" to 4" O. D., with either standard or heavy duty studs. Chrome, Cadmium or Black Oxide finishes can be supplied; also seals where conditions require.



TYPE S Standard Stud



TYPE H Heavy Duty Stud

Provides an average of 20% greater bending resistance of the stem where severe operating conditions exist, at no extra cost.

ORANGE CAM YOKE ROLLERS

Ideal for yoke mounting in all types of machinery involving cam action, or control of machine elements requiring guide or support rollers. Available in 18 sizes from ¾" to 4" O.D. and can be furnished with Chrome, Cadmium or Black Oxide finishes. Also supplied with seals where required.

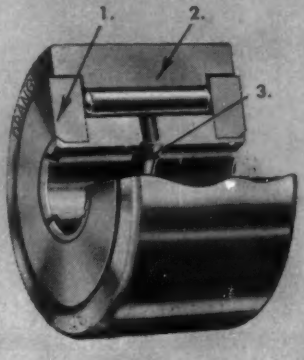
●

WRITE FOR 44-PAGE ENGINEERING REFERENCE MANUAL giving full specifications on Orange Cam Followers and Yoke Rollers, plus complete line of Orange Roller Bearings.

1. Staked End Plate. The inner race is zone hardened on the roller path for wear-resistance, while the ends remain more ductile to permit substantial staking for self-retention. Eliminates displacement caused by flimsy rings or insufficient deformation of thru-hardened inner races.

2. Heavy outer race thru-hardened to carry heavy loads.

3. Ample lubrication through center channel.



ORANGE ROLLER BEARINGS

ORANGE ROLLER BEARING CO., Inc.
556 Main Street, Orange, N. J.

Needle Bearings — Staggered Roller Bearings
Journal Roller Bearings — Thrust Roller Bearings
Cam Followers

S. S. White DRIVE AND CONTROL IDEAS FOR ENGINEERS

Tips on better designing with flexible shafts

REMOTE CONTROL AND POWER DRIVE:

Retractable hard top simplified by flexible shafts.

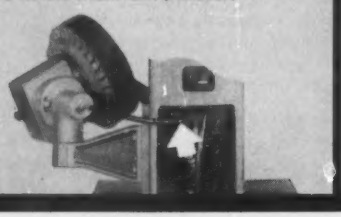
In the Ford Fairlane 500 Skyliner, the roof retracts into the trunk, and the trunk lid closes and locks. All this is done automatically, within 40 seconds. Powering this ingenious mechanism are six 3/16" high speed, remote control flexible shafts, driven by three reversible electric motors.

The use of flexible shafts enabled the designers to use only one motor to drive each pair of actuators, thus solving synchronization problems and at the same time cutting down on the number of motors needed.

Flexible shafts (1) and (2) rotate the trunk lid locking screws in and out of engagement. Flexible shafts (3) and (4) drive a pair of screw-jack actuators to raise or lower the trunk lid. Flexible shafts (5—not shown) and (6) drive a pair of actuators and their associated linkage to raise or retract the roof.

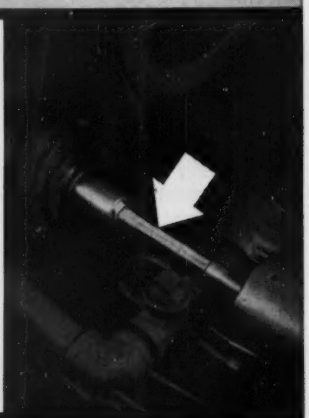
POWER DRIVE:

Powering a movable component . . . is easily accomplished with flexible shafts. Position of barrel type feeder on this new Detroit Power Screwdriver is highly adjustable, because it is driven by a flexible shaft. Power take-off is at the main drive motor.



COUPLING:

Solve alignment and vibration problems . . . with S. S. White coupling shafts — short pieces of flexible shafting without companion casings. Here is one being used between an adjustable pulley and a gear pump.



1057

S. S. White®

IN FLEXIBLE SHAFTS

S. S. WHITE INDUSTRIAL DIVISION Dept. 4
10 East 40th Street, New York 16, N.Y.

Selection of S. S. White standard flexible shafts: complete description and application data available. **Write for bulletin 5801.**

WRITE FOR COMPLETE DATA!

Selection of specialized flexible shafts to meet unusual requirements: useful shaft data and also information on how to take advantage of S. S. White engineering services. **Write for bulletin 5601.**

off than that for other varnishes. Supplied as 59 per cent solids in diacetone alcohol, varnish has a higher flash point than xylene or toluene impregnating solutions. When used with other Class H components in power transformers, servomechanisms, and electronic devices designed for high temperature rise, excellent thermal stability of 980 varnish permits small, lightweight, more reliable units. Dow Corning Corp., Midland, Mich. T

Circle 718 on Page 19

Plastic Gate Valve

Penton unit
operates to 125 C

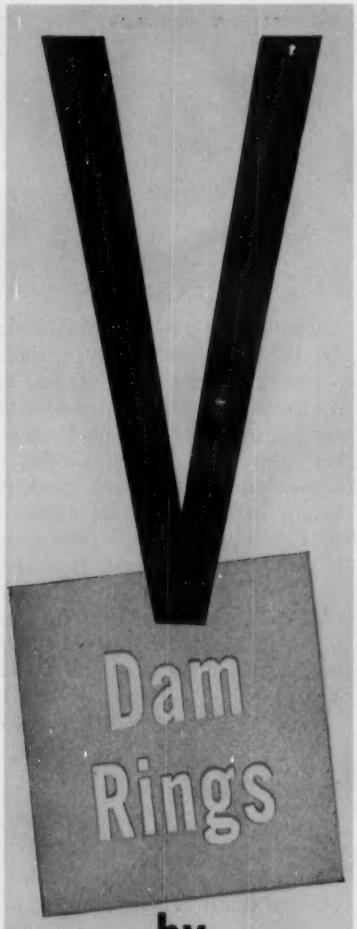
Throttleable valve of Penton plastic does not lose tensile strength or hardness and is not subject to elongation at temperatures to 125 C. It generally resists all inorganic acids except fuming nitric and fuming sulfuric. Valve is particularly suited for use in process operations that require continuous exposure to corrosive media at elevated temperatures. It offers combined features of straight-through, no-pressure-drop flow with close throttling control. Sizes range from ½ to 2 in. with socket-weld, flanged, or screwed ends. Vanton Pump & Equipment Corp. Div., Cooper Alloy Corp., Hillside, N. J. D

Circle 719 on Page 19

Silicon Mesa Diodes

have fast
switching time

High-voltage silicon mesa diodes switch from 10 ma forward current to 6 v reverse in 4 millimicrosec maximum. Diodes have broad application throughout the computer industry where there is a need for



by
LINEAR

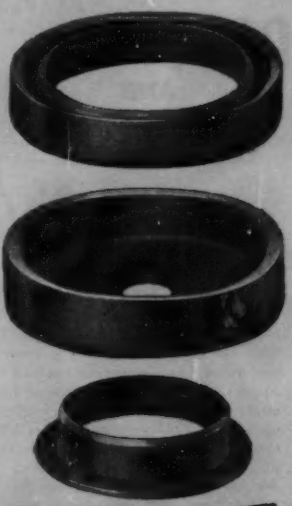
in modern elastomers—both homogeneous and fabric-reinforced. V-Dam rings provide excellent sealing against high pressures, particularly in heavy duty applications. Long life and ability to withstand severe environments means less downtime—lower maintenance costs.

LINEAR—specialists in close-tolerance molding in all of today's modern elastomers . . . to seal under virtually any severe environmental or operating conditions.

The LINEAR engineer can help with all your sealing problems . . . call him, or write for further information.

"PERFECTION IN RUBBER"
LINEAR
LINEAR Inc. STATE ROAD & LEVICK ST. PHILA. 35, PA

Circle 523 on Page 19



by
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in Viton A, Vyram, Polyurethane, and other unusual elastomeric materials having excellent resistance to many petroleum oils, synthetic lubricants, fuels, phosphate and silicate ester fluids—in a temperature range of —40° to + 500°F.

LINEAR—specialists in close-tolerance molding in all of today's modern polymers . . . in both fabric reinforced and homogeneous materials.

These are low friction seals. For further help, call the LINEAR engineer.

"PERFECTION IN RUBBER"
LINEAR
LINEAR Inc. STATE ROAD & LEVICK ST. PHILA. 35, PA

Circle 524 on Page 19

3rd in a series of POWDERED METAL PARTS applications by REESE

COST AND SERVICE STORY

behind Reese Powdered Metal Knobs for Bernz-O-Matic Ceramic Grill

From John B. Spiggle, Purch. Agent for the Otto Bernz Co., Inc.: "Our present brass powdered metal knob was evolved from a smaller knob that was re-designed from a screw machine part to reduce cost. When we required a larger but similar knob on another product, we immediately thought of powdered metal. Reese received the order for this new part because their price and delivery were better than others who had quoted. We have continued to do business with Reese because their prices have been in line and their service and quality better than our other sources for powdered metal parts."

FREE BROCHURE "How to Cut Precision Parts Cost with the Remet Powdered Metal Process" shows how the Reese Corp. can help you. Send for your copy today.

Remet

REESE METAL PRODUCTS CORPORATION
537 Howard Ave., Lancaster 11, Penna.

Gears • Pinions • Cams • Ratchets
Oilless Bearings • Bushings • Machine and Structural Parts in
COPPER • BRASS • IRON • ALLOY STEEL • NICKEL SILVER • COPPER INFILTRATED IRON

Circle 525 on Page 19

The most frequently used reference for design and manufacturing data. For 45 years "The Bible of the Mechanical Industries." Over 1,250,000 copies sold.

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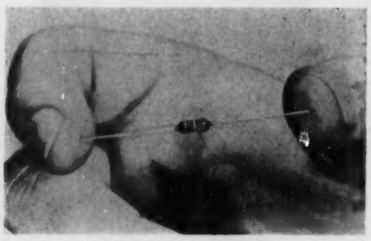


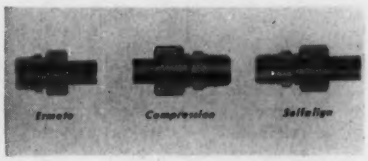
fast switching diodes with high reliability. Fast switching capability is combined with extremely low capacitance of only 2 mmf maximum, making the units desirable for high-frequency applications. Diodes, in subminiature, hard-glass package, feature high peak inverse voltage of 75 v. Operating temperature range is −65 to +150 C for both models. They withstand 20,000 g acceleration and 1000 g shock. **Semiconductor-Components Div., Texas Instruments Inc.**, P. O. Box 312, Dallas, Tex. P

Circle 720 on Page 19

Tubing Insert

for soft plastic tubing

Plastic tubing insert, available in brass or stainless steel, prevents rupture of polyvinyl chloride, polyethylene, and nylon soft plastic tubing when used with brass or steel fitting connections. Insert is available in seven sizes for use with



plastic tube sizes from ¼ to ⅝ in. with 1/16-in. wall, in ¾-in. size with 3/32-in. wall, and in 1-in. size with ⅛-in. wall. **Weatherhead Co.**, 128 W. Washington Blvd., Ft. Wayne, Ind. J

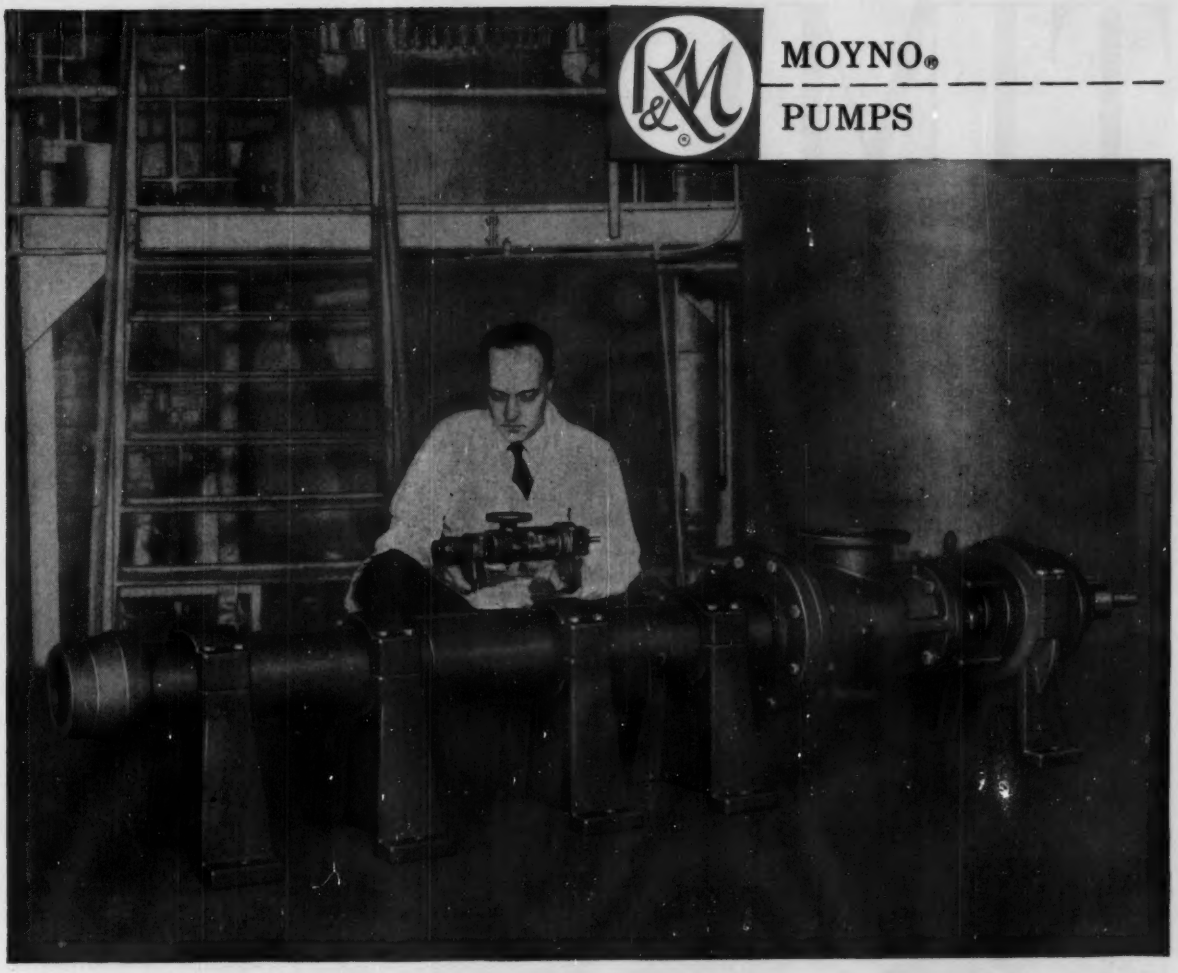
Circle 721 on Page 19

Servo Motor Gearheads

in planetary and spur units have 2000-hr life

Planetary gearheads are available with ratios to 2500:1 with torque rating of 25 oz-in. and maximum backlash of 10 min. Over-all length is only 0.8 in. Spur units are available with ratios to 4000:1. In the

MOYNO®
PUMPS



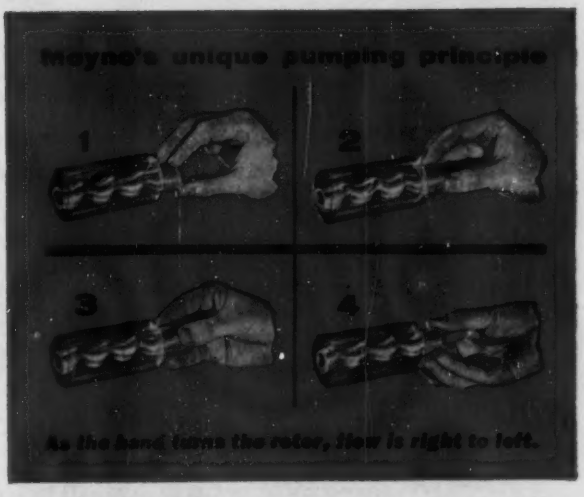
MOYNO® PUMPS

capacities: from 1/100 to 500 gpm
pressures: up to 1000 psi

MOYNO pumps are available in nine sizes with capacities ranging from minimum metering flow to 500 gpm and pressures from zero to 1000 psi. Positive displacement delivers uniform discharge without pulsation, agitation or turbulence. Solutions ranging from thin watery slurry to extremely viscous paste, corrosives, abrasives and even solids in suspension are economically handled without excessive pump wear.

MOYNO's unique *"progressing cavity"* principle with only one moving part and special resistant internal parts slashes pump maintenance costs on problem materials that often ruin other pumps. Almost any substance that can be forced through a pipe can be pumped by a MOYNO.

To learn how a MOYNO can cut your pumping costs, write today for Bulletin 30-MD



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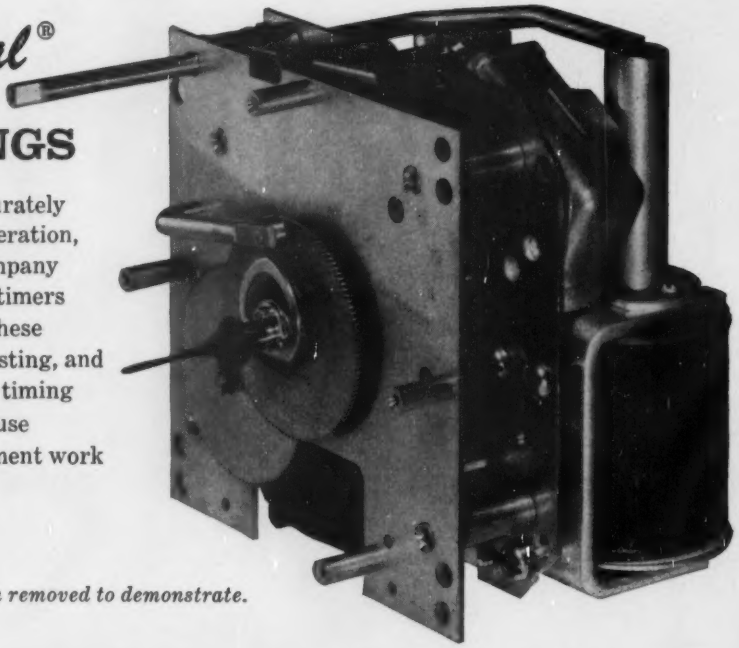
motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

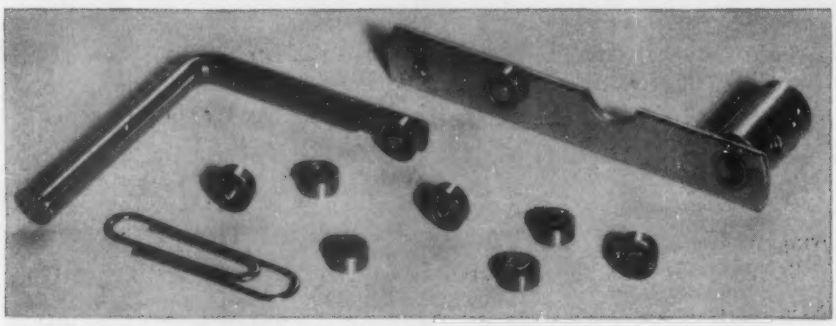
TIME AND PRECISION BEARINGS

HEIM *Unibal*® MINIATURE BALL BEARINGS

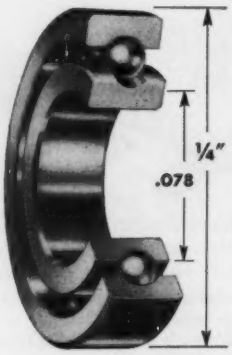
For measuring elapsed time accurately to within .001 of a second per operation, The Standard Electric Time Company manufactures precision electric timers which "split the split second". These timers are used in laboratory, testing, and production work wherever close timing is a requisite. Thousands are in use whenever research and development work must be accurately timed.



Dial and case have been removed to demonstrate.



Heart-shaped cams are attached to both hands of the timer. Miniature Heim Ball Bearings act as cam drivers, or friction-free rollers, to reset the timer after each use.



Unibal Ball Bearings Now Available in Miniature Sizes.

The simplified construction of the Heim Ball Bearing permits its assembly with just the inner and outer races and a full complement of balls. Insertion grooves, retainer rings, and spacers are eliminated.

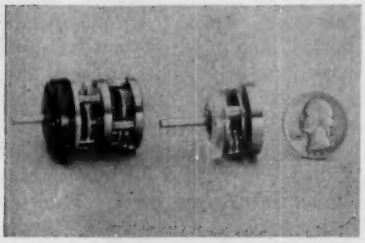
Shown above are bearings with flush races, bearings with extended inner races for clevis mounting. The two reset arms, as used by Standard, indicate the method of mounting the bearings.

THE HEIM COMPANY

FAIRFIELD, CONNECTICUT

Save money on your ball bearing requirements with Heim Unibal.

HEIM BEARINGS ARE SOLD BY THE MOST RESPONSIBLE BEARING DISTRIBUTORS IN THE U.S. AND CANADA



low-ratio series, up to 37:1, over-all lengths of 0.5 in. for torque rating of 25 oz-in. and 0.609 in. for torque rating of 50 oz-in. are available. Maximum backlash is 15 min. Units in high-ratio series from 38:1 to 4000:1 have torque rating of 50 oz-in. and maximum backlash of 30 min. All units are guaranteed for 2000 hr operating life. U. S. Gear Corp., 81 Bay State Rd., Wakefield, Mass. B

Circle 722 on Page 19

Teflon Film Tape

is self-lubricating

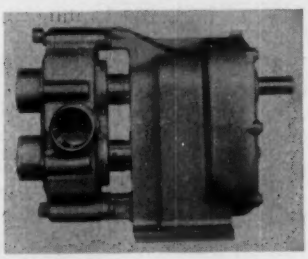
No. 423 Teflon film tape is a 2-mil film with pressure-sensitive adhesive. It can be used in electrical applications for holding and insulating where a Class 180 C tape is required, for coil wrapping, and as a conductor insulation for armature and field coils. Antistick, self-lubricating, temperature and corrosion-resistant properties allow a variety of uses. Tape is readily printable with ordinary printing inks. Interliner is provided to facilitate die-cutting into any desired shape. Permacel, Route No. 1, New Brunswick, N. J. D

Circle 723 on Page 19

Positive-Displacement Pump

is slow-speed, heavy-duty unit

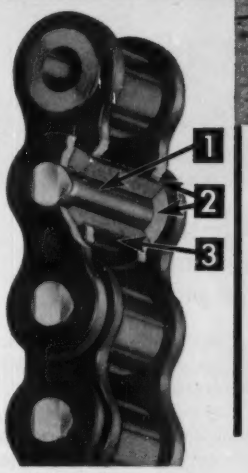
Industrial positive-displacement pump of 316 stainless steel provides slow speed, heavy duty, and long



John Deere

Found a Chain Drive That-

1. REQUIRES NO LUBRICATION
2. IS SELF-CLEANING
3. REQUIRES NO MAINTENANCE
4. OUTWEARS ORDINARY CHAIN



Critical Area 1:

PIN—Protective oil film lubricates live bearing area between pin and bushing, minimizing wear by reducing metal-to-metal contact.

Critical Area 2:

PLATES—Oil-impregnated Sintered Steel Bushings extend beyond surface of inside plates to: act as lubricated thrust bearings, control clearance, and provide an oil cushion between plates, eliminating plate galling and seizing frequently caused by misalignment of sprockets.

Critical Area 3:

SPROCKET ENGAGEMENT—Oil film on MSL Bushing exterior provides constant lubrication between sprocket teeth and chain. Whitney MSL Chain requires no rollers, as the tough oil film on the bushing surface provides smooth sprocket engagement, cushions impact and reduces drive wear.

Chain drives on farm machinery take a beating. Dust, dirt, corrosion and rust—inadequate lubrication, and hit-or-miss maintenance, all add up to "stiff joints"—the major cause of chain failure.

John Deere provides owners of its 494 and 495 Planters with extra insurance against drive chain trouble by using advanced design Whitney MSL* Self-Lubricating Chain on main drives of these machines. Because John Deere engineers recognized the advantages of MSL Chain's built-in lubrication at all 3 critical chain areas, farmers aren't bothered with the usual problems encountered in equipment drives. And they get longer chain life—up to 5 times longer—than that provided by conventional chain.

If the drive chain on your product must deliver top performance in severe operating environments, or operate with maximum cleanliness, Whitney MSL Chain can do the job. Standard and Extended Pitch MSL Chain conforms fully to ASA Standards, making it completely interchangeable with any similar pitch ASA standard chain. Write for MSL Chain Catalog today.

*Maximum Service Life

THE WHITNEY CHAIN COMPANY

a subsidiary of FOOTE BROS. GEAR AND MACHINE CORPORATION

4567 S. Western Blvd., Chicago 9, Ill.

POWER TRANSMISSION DRIVES

Circle 529 on Page 19

NOW AVAILABLE... Another helpful booklet on a new concept for air control

A comprehensive discussion of the 4 basic principles involved in designing an economical "control by air" system for industrial machines and processes.

Westinghouse Air Circuitry means the *control by air* rather than the mere use of it. It deals with the interlocking, sequencing, timing and segregation of events to obtain automatic or semi-automatic control. It is applicable to any automation problem on any industrial machine . . . in any industrial process. The equipment involves uncomplicated mechanical devices with few moving parts. Any mechanic can easily install and service a Westinghouse Air Circuitry system.

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WESTINGHOUSE AIR BRAKE COMPANY
Industrial Products Division, Wilmerding, Pennsylvania

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Industrial Products Division, Dept. MD-10
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pump life. Specific features include helical timing gears, twin balanced impellers, and single or dual mechanical seals. Pump is also available with packing-gland seal construction. Body and seals are drilled and tapped for pressurizing or lubricating purposes. Pump is self-priming. Each shaft is supported by three heavy-duty bearings to eliminate shaft deflection. Unit is initially available with capacities to 100 gpm against head pressures of 200 psi. **Pump Div., Waukesha Foundry Co.**, Dept. 76, Waukesha, Wis. K

Circle 724 on Page 19

Connecting Devices

for micromodules and other miniaturized circuitry

New connecting devices for micromodules and other miniaturized circuitry have gold-plated contacts which increase their reliability in dry circuitry and allow for easier soldering. Insertion force is less than 0.5 lb, and less than 0.25 lb

per contact for withdrawal. Connecting devices include module headers, module receptacles, straight-through connectors, and right-angle connectors. Designed for 0.05-in. printed-circuit grid, connectors afford high contact density. **Molded Insulation Co.**, 335 E. Price St., Philadelphia 44, Pa. E

Circle 725 on Page 19

Footswitches

maintained-action units have high electrical rating

Features of two Hi-Treadlite maintained-action footswitch models include reliable push-on, push-off operation, high electrical rating, and simplified installation wiring. Model HT-52-D has a single-pole, double-throw action with 20-amp electrical rating at 125, 250, and

Circle 530 on Page 19

wherever high-performance clutches and brakes are required you'll probably find FAWICK!

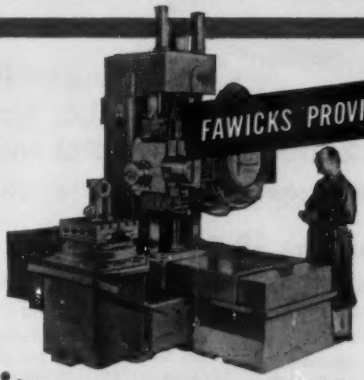
FAWICKS BOOST PRODUCTION 250%

Precision Welder and Flexopress Corporation, Cincinnati, included FSPA (FAWICK Standardized Press Application) as original equipment on its new Flexopress which stamps rotor laminations for hermetic motors at a rate of over 300 pieces per minute — 2½ times more than the long-existing maximum for this operation. Instant, positive clutch and brake action allow the manufacturer to realize full operating potential of the advanced feed and slide construction. Overall result is a major production breakthrough for the appliance manufacturer who uses the press.

FAWICKS ELIMINATE MAINTENANCE

Airflex Clutches have provided trouble-free power transmission on firebrick presses for nine years at Kaiser Refractories & Chemicals Division, Moss Landing, California. Simplified, drum-type design and self-adjusting action have eliminated the frequent overhauls and replacements that were necessary with the mechanical clutches previously used. Push-button operation, instant clutch response and greatly reduced press down-time have resulted in an overall production increase of 25 per cent.

FAWICKS PROVIDE FULL AUTOMATION



The Kearney and Trecker Milwaukee-Matic incorporates three FAWICK Magnetic Clutches in the spindle head for split-second starts, stops and reversing actions vital to its precision-timed operation. The Magnetics' instant response to automatic controls, shock-free operation and full transmission of torque contribute to a fully automated program of machining operations in which 31 tools are selected, brought to the work and changed in scheduled sequence.

For machines that demand clutch and brake action of the highest order, specify FAWICK—best qualified to solve your power transmission problem. Contact your nearest FAWICK representative, or the Home Office, Cleveland, Ohio.

FAWICK AIRFLEX

INDUSTRIAL CLUTCHES AND BRAKES

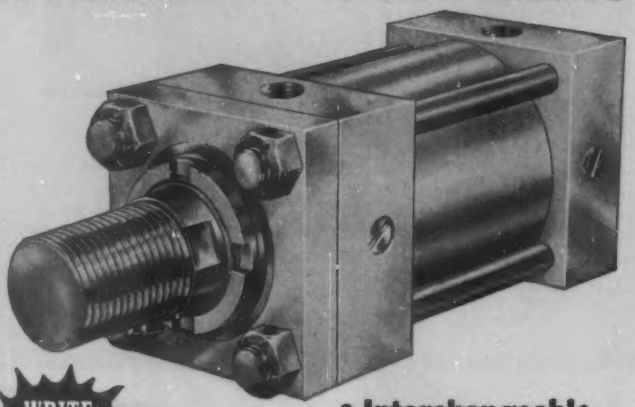
FAWICK AIRFLEX DIVISION
FAWICK CORPORATION
9919 CLINTON ROAD • CLEVELAND 11, OHIO
Fawick Canada, Ltd., 60 Front St., West, Toronto, Ont., Canada

For Smooth, Precise, Sure Power

SP

NEW

HIGH-PRESSURE HYDRAULIC CYLINDERS



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Self-contained unit, easy to remove for servicing—no need to loosen tie rods or dismantle the cylinder.

"Clinch-Tite" End Seal

Maintains a leakproof seal at all pressures. An increase in internal pressure reduces the radial clearance at the pilot fit, eliminating "O" ring extrusion.

Interchangeable Cushion Adjustment and Check

Permits maximum installation flexibility; no clearance problem due to space-saving flush design; easy to adjust.

Heli-Coil® Insert Piston Lock

Permits quick, easy rod service without loss of thread strength; conforms to rigid aircraft standards.

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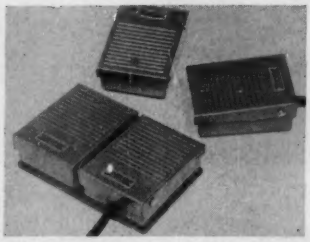


460 v ac. No. HT-54-D features double-pole, double-throw operation with 10-amp rating at 125 v ac and 5 amp at 250 v ac. Both models measure 3½ x 2½ x 1¼ in., have strong steel housing and skidproof, sponge-rubber base pad. Dual or twin types of both models are also available. **Linemaster Switch Corp.**, 432 Woodstock Terrace, Woodstock, Conn. B

Circle 726 on Page 19

Electrical Tape

has high resistance to cold flow

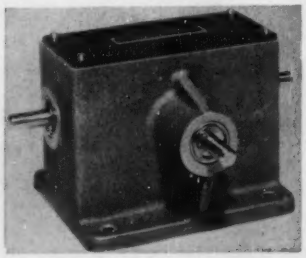
Scotch brand No. X-1099 pressure-sensitive, fully cured flexible epoxy electrical tape has a backing of 100 per cent solids epoxy resin reinforced with 0.002-in. glass cloth. Because of high resistance to cold flow, good conformability, high electric strength and good physical properties, tape is recommended for applications which require electric strength of a continuous film of epoxy resin and physical strength of glass cloth at Class F operating temperatures. **Minnesota Mining & Mfg. Co.**, Dept. S9-481, 900 Bush Ave., St. Paul 6, Minn. J

Circle 727 on Page 19

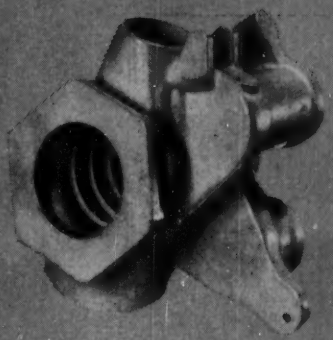
Bevel Gear Boxes

are available in ratios from 1:1 to 3:1

BA-5 heavy-duty bevel gear boxes are for shaft sizes of ⅛ to ¼-in. diam. Ratios range from 1:1 to 3:1.



Is your new design complex?



...ask Arwood about investment casting

When you can't simplify the part any more without sacrificing function...

When the production people tell you it will be too costly to machine...

When you think you could cut production costs by making several parts as a single piece...

When function calls for a tricky shape but the intended service makes you specify, a hard, strong, tough-to-work alloy...

When any or all of these design problems are keeping you awake nights... then is the time to consider making the part an Arwood precision investment casting.

Here's why...

Investment casting by Arwood lets you stop worrying about *how to make* the part. You can design for function and end use... Arwood will give you the shape you need, in the quantities you need, from a few hundred to many thousands. Arwood casts all the ferrous and non-ferrous metals and alloys, from aluminum and magnesium right through to stainless steel and cobalt- and nickel-base superalloys.

Write today for your free copy of the new 44-page Arwood "Practical Guide to Investment Casting". It provides all the information you need to evaluate the technique and use it to help solve your design problems.

MACHINE THE SIMPLE... CAST THE COMPLEX

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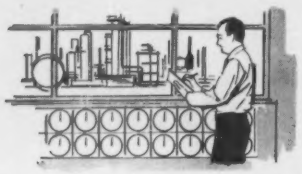
SPECTROL PRECISION MECHANISMS

One Man, Black Boxes, and Process Control



Speeding up instream process control frequently requires more ingenuity than cash.

Bearing on this point, Spectrol recently made a number of cleverly engineered black boxes for one of the country's leading refineries. This device, known as an Indicating Process Monitor, takes inputs from flow, temperature, and pressure transducers, measures them and delivers any necessary corrective action through a servo loop. The information is visually presented on dials incorporating adjustable set points. Output from this Spectrol black box also drives a variety of data handling, display, and recording equipment.

Here's how it works. After a given physical quantity is transduced to a voltage, it passes through a difference sensing network to a servo-amplifier. The amplifier output voltage operates a motor and speed reducer which drives several Spectrol precision potentiometers ganged on a common shaft. The output voltage of one of these potentiometers has a linear relationship to the indicator setting and is used for negative feedback. The difference between this voltage and the transducer input voltage becomes the servo error signal. Rotation of the system continues until the error signal becomes zero and the indicator reads the new value of the physical quantity under consideration. Meanwhile, other potentiometers on the shaft send voltages to various instream control devices which raise and lower pressures, temperatures, and so forth until the process takes place at the desired rate. Static accuracy is 0.2%.

The visual monitoring task of the observer is simplified by mounting the meter on an easily rotated chassis so that anticipated output in terms of arbitrary units from 1 to 100 can always be read with the needle in an upright position. This feature minimizes observer error where several predetermined outputs are viewed continuously. If black box A is set at 85, B at 40, and C at 100, the operator merely rotates each Spectrol precision mechanism until the respective needle reads the value in an upright position. He can quickly note and correct any processing circuit that leaves boundary conditions.

Of course, these devices are readily adaptable to the more esoteric tasks of reading fuel flow, pressure and temperature in a missile launch blockhouse. Here, human engineering of visual displays is of vital concern.

In a nutshell, advantage of this instance of Spectrol's unique approach to automation is a package one-fifth the size for 40% less than the way the refinery used to do the same job.

More information, including a helpful 8 page booklet, on this and other Spectrol precision mechanisms designed for use as functional sub-systems is yours for the asking. Simply call your nearest Spectrol sales engineering representative or address Department 571.

8

SPECTROL

ELECTRONICS CORPORATION

Sales engineering representatives in principal cities.

1704 S. DEL MAR AVE., SAN GABRIEL, CALIFORNIA

Circle 534 on Page 19

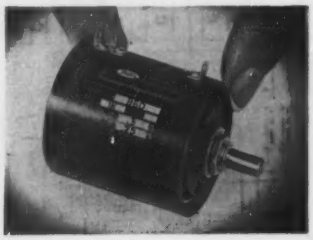
Ball-bearing and/or oilless-bearing types are available, with a range of shaft outputs and inputs. **PIC Design Corp.**, 477 Atlantic Ave., East Rockaway, L. I., N. Y. D

Circle 728 on Page 19

Ten-Turn Potentiometer

is low-cost, 1 13/16-in. unit

Ten-turn precision wirewound potentiometer, Model 860, is available in ranges from 50 to 400,000 ohms, and up to 1 megohm on request. The low-cost, 1 13/16-in. unit has



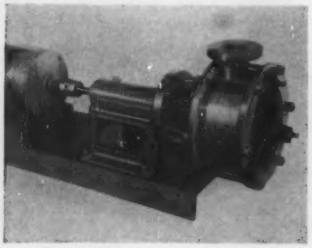
standard linearity tolerance of ±0.25 per cent with tolerance of ±0.02 on special order. Unit operates over temperature range of −55 to +105 C. Up to 108 additional terminals can be added to standard unit for special applications. Sleeve bearings at both shaft ends are standard, and shaft diam is ¼ in. **Spectrol Electronics Corp.**, 1710 S. Del Mar Ave., San Gabriel, Calif. M

Circle 729 on Page 19

Centrifugal Pumps

all-plastic units handle 300-F solution temperatures

Polypropylene centrifugal pumps possess excellent resistance to solvents, greases, oils, and many common acids and chemicals at high temperature. Available in two sizes, pumps provide capacity range from 2 to 80 gpm and accommodate solution temperatures to 300 F. Lightweight, high-strength, rigid, mar-

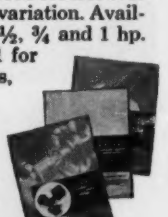


3 PULLEY DESIGNS

CONSTANT SPEED — Hi-Lo Automatic Pulleys employ an exclusive cam and cam follower assembly to maintain desired speed ratio over a wide range of load variation. They provide high shock absorbency against sudden changes and eliminate "drag" due to temporary overload. Sizes: ¾ to 5 hp. at 1750 rpm. Speed ratios: 1.75 up to 2.6 to 1. *Request Bulletin A458.*

HIGH RATIO — Hi-Lo Hi-Ratio Pulleys provide an extremely wide range of speeds for constant speed motors up to 1 hp. Double variable pitch feature automatically adjusts driver and driven belt speeds in accordance with distance from motor. Sizes and speed ratios: fractional to ½-hp. model up to 6 to 1, fractional to 1-hp. model up to 7½ to 1. *Request Bulletin B455-2.*

ECONOMY — Hi-Lo FHP Pulleys are low cost, high quality, compact units. They feature exclusive Hi-Lo cam design for positive speed control over a wide range of load variation. Available in three sizes: ½, ¾ and 1 hp. Speed ratios: 2 to 1 for ½ and ¾-hp. models, 2½ to 1 for 1-hp. model. *Request Bulletin C458.*



Give application details for specific information. Ask for prices.

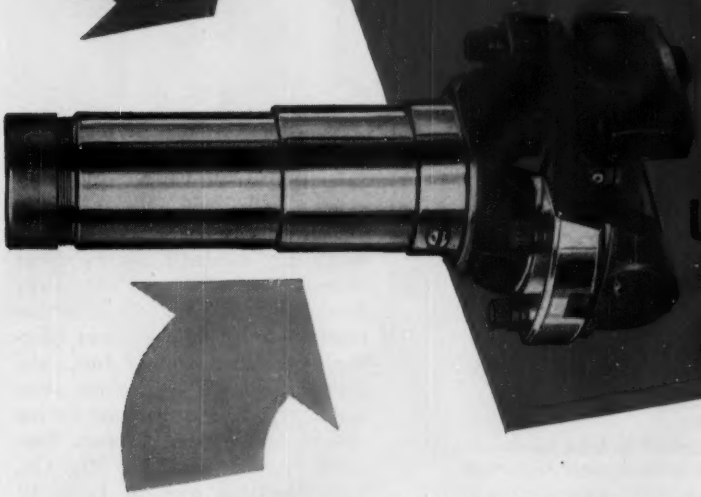
Manufactured By HI-LO MANUFACTURING COMPANY

Nationally Distributed By LOVEJOY FLEXIBLE COUPLING COMPANY 4968H West Lake St. Chicago 44, Ill.

Circle 535 on Page 19

MORE MUSCLE IN A SMALLER PACKAGE... THE NEW

BLOOD BROTHERS "58WB" UNIVERSAL JOINT



To meet new drive line requirements on its 1960 model trucks, a major truck manufacturer needed a special, lightweight but strong universal joint—a unit that would provide greater torque capacity without increasing swing diameter. Rockwell-Standard engineers were consulted, and in a cooperative effort the new "58WB" was developed. It is now being used on several models in the manufacturer's 1960 line.

The design of the new "58WB" is applicable to medium-weight trucks, off-highway equipment, small crawlers and front-end loaders of approximately 1½ yards capacity. It can be made up as a complete drive line, furnished as a component part for a manufacturer's own drive line, or utilized in close-coupled drives. The "58WB" offers these outstanding advantages:

★ **More capacity than any joint of comparable size.** The "58WB" provides 39,000 inch pounds torque capacity with a swing diameter of only six inches!

★ **Key-type yoke.** Requires only four bolts for installation on original equipment. Saves downtime for repairs.

For more details about the new "58WB" or for help in solving any problems involving universal joints or drive lines, write or call us today.

Another Product of...

ROCKWELL-STANDARD
CORPORATION

Universal Joint Division, Allegan, Michigan

Announcing . . .

New Production Capacity

To Serve You Better

Large Generated Gears

SPUR—HERRINGBONE—HELICAL

for a wide range of industrial applications

Gears which must operate smoothly and without vibration at higher speeds and under greater loads must correspondingly be more accurate in tooth profile and spacing.

H & S Generated Gears provide these results.

To meet increasing customer demands, Horsburgh & Scott has broadened its manufacturing capacity and tooled to produce *large* Generated Gears up to 125" diameter.

Offering the same high quality standards which characterize the complete H & S Gear line, production capacities for large Spur, Helical and Hobbed-Herringbone Gears are now available in the following dimensions:

Up to 80" outside diameter at 1 DP
Up to 90" outside diameter at 1¼ DP
Up to 100" outside diameter at 1½ DP
Up to 125" outside diameter at 2 DP

Face widths up to 42", depending on helix angle.

Take advantage of this new capacity, and our long experience as specialists in this field. Send your specifications, drawings or plans — or tell us about your power transmission problem. Our technical staff will promptly consider your requirements and render recommendations and quotations.

THE HORSBURGH & SCOTT CO.

GEARS AND SPEED REDUCERS

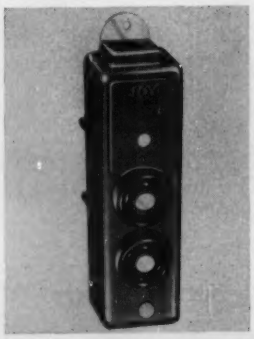
5112 Hamilton Avenue • Cleveland 14, Ohio

resistant casing is totally protected by a cast-iron frame. Pumped fluid contacts only facings of rotating and stationary rings which can be provided in Teflon, carbon, ceramic, or Stellite. Stationary rings can be reversed for additional use. Easy maintenance is a feature of the units. **Vanton Pump & Equipment Div., Cooper-Alloy Corp., Hillside, N. J.** D

Circle 730 on Page 19

Pendant Switch

in two-button model is watertight



Safe pendant switch is now available in a two-button model. Each button is integral with housing, which is of molded two-piece Hycar to insure watertight and electrically insulated operation. Unit is impervious to oil or acids, and effectively excludes water, dust, and grime. Switch is of precision snap-action type and is designed for use on circuits to 460 v, 20 amp. **Electrical Products Div., Joy Mfg. Co., 1201 Macklind Ave., St. Louis 10, Mo.** I

Circle 731 on Page 19

Transistor Pad

for mounting standard transistors

Transistor pad is precision molded of mineral-filled diallyl phthalate which conforms to MIL-P-14D (MDG type) and MIL-P-4389. Nominal tensile strength is 5500 psi. It resists continuous exposure to 400 F, and offers high dielectric strength. Pad provides an excellent mounting base for standard transistors. Spherical feet act as standoffs and provide necessary lead lengths and air space for thermal

Circle 537 on Page 19

interchangeable with all standard JIC cylinders

With the introduction of the ALL NEW T-J Squair Head, Tomkins-Johnson now offers industry the most complete design range of air and hydraulic cylinders. Presently available in bore diameters from 1½ to 8 inches, the T-J Squair Head is an interchangeable cylinder which produces maximum force and efficiency, with minimum pressures... and is also adaptable to the use of low pressure oil as the working medium. Write to The Tomkins-Johnson Co., Jackson, Michigan, for Bulletin #SQ 10-58 and complete details.

CHECK THESE 10 POINTS OF T-J SUPERIORITY

1 One Piece Piston

2 Hard Chrome Cylinder Bore and Piston Rods

3 High Tensile Steel Tie-Rods

4 Cushion Adjusting Screw, Externally Adjustable

5 New Super-Cushion for air, or Self-Aligning Master Seal for Oil (T-J Patents)

6 Solid Steel Heads and Mounting Plates Standard all Models

7 Port Design Allows Minimum Pressure Drop on Inlet or Outlet

8 Chevron Type, Self-Adjusting Rod Packing

9 Piloted Packing Gland—Absolute Alignment

10 Piston Rod, Extra Strong—Polished and Chrome Plated for Efficiency and Protection

T-J TOMKINS-JOHNSON

Failure of any part of a missile—be it the mighty Atlas, Jupiter or Thor—can mean failure of the mission. That's why the complex connections in the ducting systems of these and other missiles are silver brazed. These connections must stand up under 6,000 psi; they are tested to 12,000 psi.

In lines made to specifications by Flexonics Corporation, Maywood, Illinois, silver brazing joins a corrugated flexible pressure carrier, a braid sleeve and a coupling nipple—all of stainless steel; it permits joining all of these elements of the assembly without danger of annealing the pressure-carrying flex or the restraining braid as welding might do.

Assemblies designed for 6,000 psi operating pressure are required to withstand a 12,000 psi test and take four times their normal operating pressure before failure. They may also be required to pass a flame test in order to meet specifications.

The silver-brazed connections are used on hydraulic and pneumatic systems, fuel drain lines and vent tubes. Some of these applications involve rigorous service with extreme pressure shocks accompanied by sudden elevations of temperature, which may go from −60° to 400-600° F in a matter of seconds.

A more "high level" endorsement of Handy & Harman silver alloy brazing is not available. On the ground or in the air, the qualities of this remarkable metal joining method apply; strength, ease of production, cost, gas and liquid joint tightness to name a few. The entire brazing story is yours merely for the asking. Inquiries and metals-joining "problem exposure" may be addressed to Handy & Harman, 82 Fulton Street, New York 38, N. Y. We welcome the opportunity to work with you.

Your NO. 1 Source of Supply and Authority on Brazing Alloys

HANDY & HARMAN

General Offices: 82 Fulton St., New York 38, N. Y.

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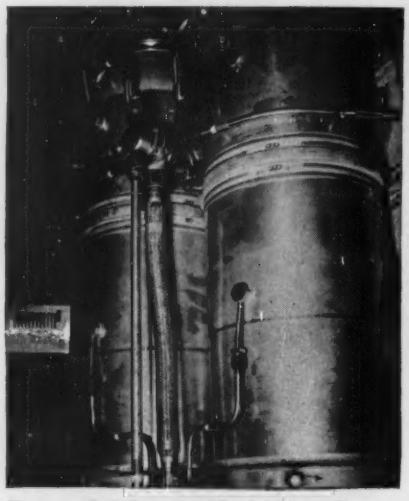
No Margin Here for joint failure!

Assemblies in ATLAS Missile

HANDY & HARMAN Silver Brazed

Intercontinental Atlas missile being made ready for launching.



Close-ups of missile section, showing silver alloy brazed ducting assembly.

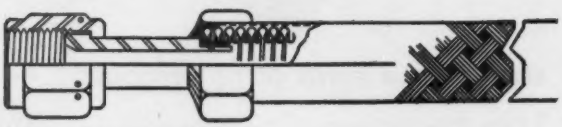


Diagram of pressure carrier.

FOR A GOOD START: BULLETIN 20.

This informative booklet gives a good picture of silver brazing and its benefits...includes details on alloys, heating methods, joint design and production techniques. Write for your copy.

insulation when hand or dip soldering. Five holes accept most combinations of lead wires. Delbert Blinn Co., P. O. Box 757, Pomona, Calif. L

Circle 732 on Page 19

Fittings and Flanges

are available in aluminum and other alloys

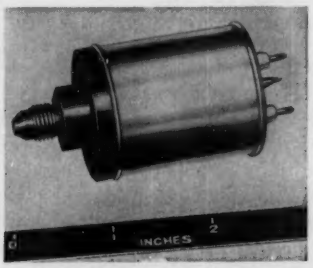
Light-wall Pipe-Mate fittings and flanges are now available in high-strength aluminum alloy, other aluminum alloys, and in nickel, Monel, copper-nickel, and other weldable alloys. They are furnished in a range of sizes from ½ to 4 in. Fittings feature long tangents that permit easy alignment of pipe and fittings and permit fabrication of completely flanged elbows, returns, tees, and crosses. Installation problems are simplified by a variety of methods of joining that can be used. Tube Turns Div., Chemetron Corp., Louisville, Ky. G

Circle 733 on Page 19

Pressure Switches

for high-temperature use

Absolute pressure switches provide electrical signals at predetermined pressure levels in air, oxygen, steam, and hydraulic and other aircraft fluids. They are capable of continuous duty at temperatures from −65 to 1000 F, and are for use in locations where high temperatures do not permit use of



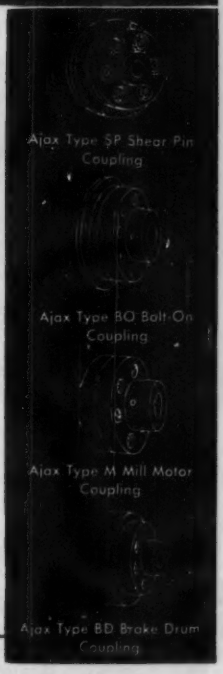
ALL THE HORSEPOWER GOES THROUGH THE COUPLING

The Basic Reason Why it Pays to Use AJAX FLEXIBLE COUPLINGS!

For Original Equipment and Replacement... It costs far less to safeguard bearings, gears, impellers, armatures, housings, and other working parts than today's high cost of repairs and shutdowns!

Whether you design, build, install, operate or service direct-connected machines, look into all extra economies of AJAX FLEXIBLE COUPLINGS.

Made in a complete line of types and sizes,—phone or write for catalog.


Ajax Type SP Shear Pin Coupling
Ajax Type BO Bolt-On Coupling
Ajax Type M Mill Motor Coupling
Ajax Type BD Brake Drum Coupling

RUBBER-CUSHIONED SLEEVE BEARING TYPE

DIHEDRAL GEAR TYPE

AJAX

AJAX FLEXIBLE COUPLING CO. INC.
102 Portage Road, Westfield, N. Y.
In Canada—The Alexander Fleck, Ltd., Ottawa
Send catalog covering Flexible Couplings.

Name_____
Concern_____
Address_____

Circle 540 on Page 19

When should COST be a factor in design investment?

The importance of cost control to any business operation cannot be minimized. However, when related to design investment — the time, money and materials spent to create new products, or to revise present products — *cost-saving becomes expensive if quality is sacrificed to price!*

Any investment in product design should be made to gain a competitive advantage, and component parts chosen to hold that competitive edge. Any deviation gives others an opportunity to take the lead.

It's only logical then, that all cost-saving suggestions in design investment must be evaluated as to effect on finished products. Sales and profits — and industry leadership — depend on such serious consideration.

COST should always be a factor in design investment . . .

but not necessarily the most important one!

So it is with the manufacture of Hansen SYNCHRON Timing Motors. Costs must be watched to remain competitive . . . but, cost-cutting will never be done at a sacrifice to established quality standards. Even with adherence to such standards, Hansen SYNCHRON Motors are able to compete with similar products.

The result of engineering that has concentrated for many years on creating and applying synchronous power units to timing applications — Hansen SYNCHRON motors are manufactured under constant quality control. Each must pass 51 separate tests and inspections. Potential users can be sure of the ultimate in silent, continuous power . . . the *best* synchronous motors for industrial and commercial applications. Present users *know* it!

Investigate the advantages of Hansen SYNCHRON Timing Motors . . . with quiet, long-life performance of benefit to products you make incorporating timing devices.

SEND TODAY
for this informative folder containing specifications and technical data on all Hansen SYNCHRON motors and clock movements.

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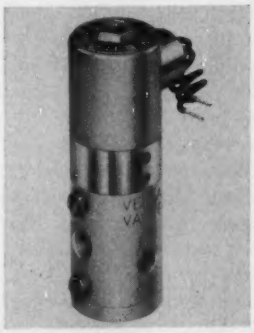
standard pressure switches. Units currently available are for operation at any pressure from 20 to 200 psi absolute, with proof pressures to 375 psi absolute. Accuracy of operating point is within 10 per cent for most models over entire temperature range. Units withstand vibration of 10 g at 1000 cps, and 40 g shock. **Consolidated Controls Corp.**, Bethel, Conn. B

Circle 734 on Page 19

Solenoid Valve

for pressures from 40 to 300 psi

Series A four-way solenoid-actuated valve is designed for pneumatic or hydraulic fluid-power applications in 40 to 300-psi range. It has full 3/16-in. diam flow area. Over 100 different variations are available in



both side ported and manifold models, with single or double-solenoid actuation. Corrosion-resistant unit is completely leakproof. Single-solenoid model shown is only 5¼ in. high by 1⅝ in. diam. All parts are interchangeable, and electrical components can be replaced without disturbing valve or connections. **Versa Products Co. Inc.**, 150 Coolidge Ave., Englewood, N. J. D

Circle 735 on Page 19

Cathode-Type Rectifier

replaces two units in television and high-fidelity

Single, full-wave rectifier, No. 5CU4, is a 425-ma unit delivering 300 v dc. The cathode-type tube replaces 5U4GB and 5Y3GT with resulting savings in tube, socket, and assembly costs. With tube voltage drop of only 24 v, unit improves regulation while adding additional

Circle 541 on Page 19

Circle 542 on Page 19→

low cost
product
insurance

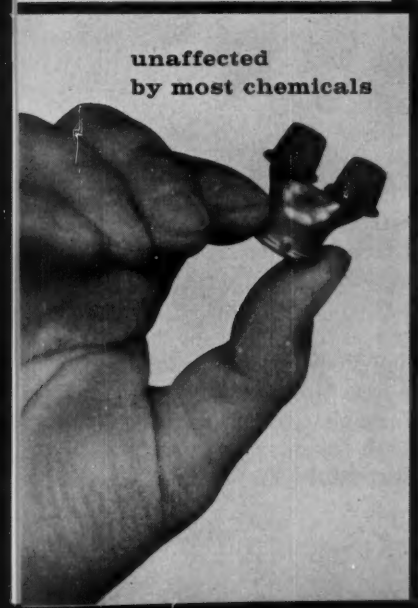
easy to apply

won't chip,
break, shred
or collapse

made of tough,
flexible Polyethylene

Caplugs

take your pick: over 600
sizes in numerous styles
and colors now in stock.



unaffected
by most chemicals

a cinch
to remove

the quickest, slickest protection for products in process, transit or storage...get a free kit full of samples in exchange for the coupon below.

CAPLUGS DIVISION,
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2201 Elmwood Ave., Buffalo 23, N. Y.

MAIL a free assortment of Caplugs, literature and prices to us, without obligation.

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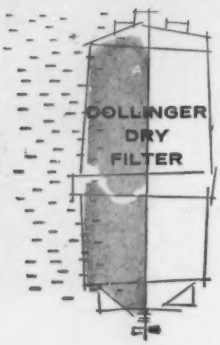

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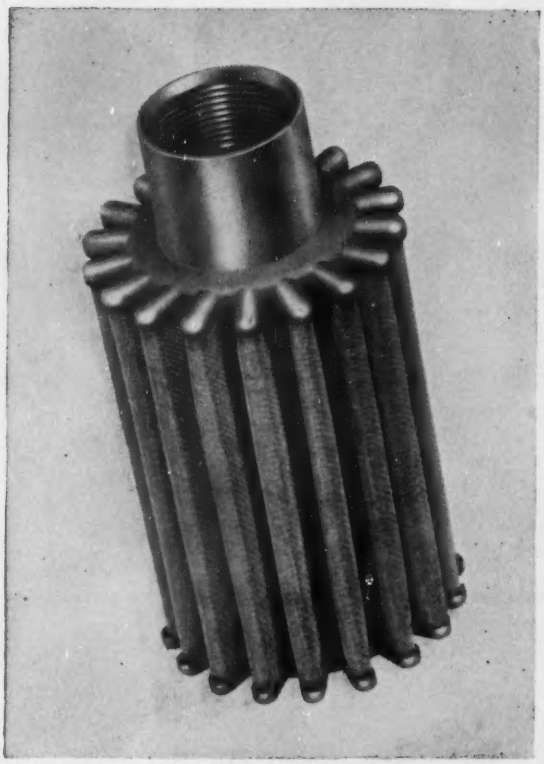
ALL NEW DESIGN AT A NEW LOW PRICE

FILTERS
for Sump Pumps and hydraulically operated equipment



DOLLINGER SUMP FILTERS are priced lower than competitors' filters for the simple reason they have been specifically designed for your needs. Leading hydraulic equipment manufacturers have already standardized on these filters for their products. Exclusive radial fin design permits larger filter capacity in smaller area. Mesh screen supplied in 60 or 100 G.P.M. Get complete details, write for Sump Filter Bulletin 330. Dollinger Corporation, 60 Centre Park, Rochester 3, N.Y.

PROTECTOMOTOR

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LIQUID FILTERS • PIPE LINE FILTERS • INTAKE FILTERS • HYDRAULIC FILTERS • ELECTROSTATIC FILTERS • MIST COLLECTORS • DRY PANEL FILTERS • SPECIAL DESIGN FILTERS • VISCOUS PANEL FILTERS • LOW PRESSURE FILTERS • HIGH PRESSURE FILTERS • AUTOMATIC VENTILATION FILTERS • NATURAL GAS FILTERS • SILENCER FILTERS

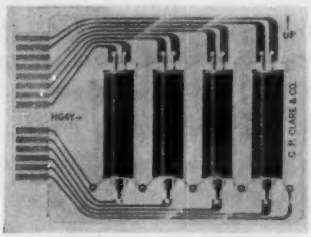
savings by operating from a transformer secondary with voltage reduced by approximately 25 v per plate. **Receiving Tube Div., Raytheon Co.**, 465 Centre St., Quincy, Mass. B

Circle 736 on Page 19

Printed-Circuit Relays

for mounting on printed-circuit board

New assembly permits single or multiple installation of mercury-wetted contact relays in small space of a printed-circuit board. It plugs into a console in the same manner as logic circuit it serves. Individual switch capsules and coils are affixed to printed-circuit board and sealed from dust, moisture, and tampering



by application of tough vinyl coating. **C. P. Clare & Co.**, 3101 Pratt Blvd., Chicago 45, Ill. I

Circle 737 on Page 19

Limit Switches

incorporate new yoke actuator

Two maintained - contact limit switches, each utilizing a new actuator, are included in LS and 200 LS series. When moved from either extreme position toward the other, actuator causes internal switching unit to transfer and maintain circuit, making switches suitable for applications requiring automatic reversal of traverse on reciprocating

70% drop in costs with powder metallurgy

Before Dixon Sintaloy entered the picture, exactly nine operations were required to make this air compressor valve guide (shown lifesize) by former conventional stamping and machining methods. Dixon Sintaloy reduced the operations to four — briquetting from iron powder, sintering, heat treating, and finishing both surfaces for flatness and parallelism.

Former costs were cut to less than one-third. Tolerances were held well within allowable limits with increased part-to-part uniformity. In addition, it then became possible to redesign the piece for even greater operating efficiency, while also effecting a substantial saving in metal.

Look again at the part. The ends of those six fingers are bearing surfaces subjected to constant rubbing. But the surface hardness imparted by heat treating, plus the self-lubricating qualities of Dixon Sintaloy's L-1004 Alloy, resulted in no perceptible wear after five months of field operation.

The parts were inspected, carefully packed, and delivered by Dixon Sintaloy ready for final finishing. Former production facilities were freed for more profitable work.

This is just one more of the many cases which make Dixon Sintaloy Powder Metallurgy Services well worth investigation, particularly if you are producing parts in which its many advantages seem even remotely attainable. The illustrated brochure will give you facts, figures, design data. Write for it today.

DIXON SINTALOY INC.

a subsidiary of The Joseph Dixon Crucible Company

535 Hope Street Stamford, Connecticut

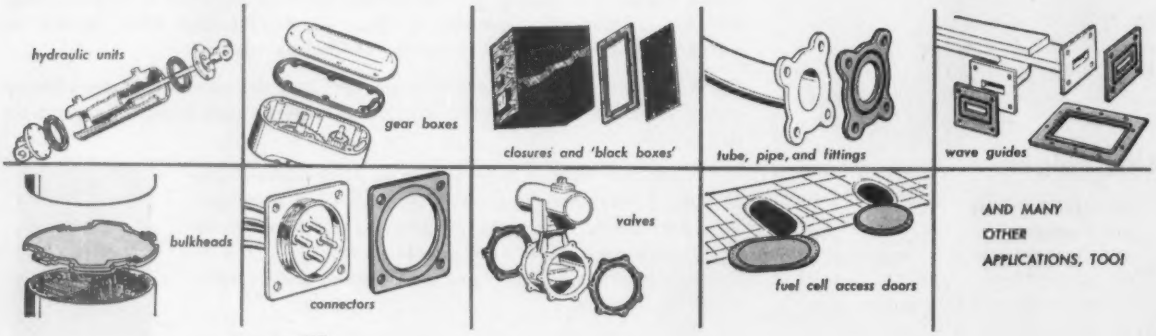
Circle 544 on Page 19

LEAKS *CAN* BE STOPPED!

Safe, sure sealing is vital in today's high performance machines, aircraft, missiles, ground support equipment and processing equipment and *there* is a better way to seal them . . . GASK-O-SEALS.

The Gask-O-Seals shown here are static seals that can actually provide sealing that will exceed hermetic top specifications. Yet, they are mechanical, can be removed, and reused. *Controlled confinement* of the rubber makes them superior to other seals.

The "typical" applications shown are just a few of the ways Gask-O-Seals are being used. Practical, *truly* economical, no-leakage sealing. If you want to *seal* for *sure*, find out about Gask-O-Seals. Just drop us a line or use the reader service card.

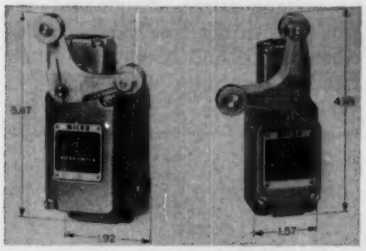


Parker SEAL COMPANY

CULVER CITY, CALIFORNIA and CLEVELAND, OHIO

A DIVISION OF PARKER-HANNIFIN CORPORATION

Circle 545 on Page 19



mechanisms. Actuator heads can be mounted in four positions, 90 deg apart. Actuator can be rotated 360 deg, positively locking in any position. Switches can be replaced easily in a few seconds, with no electrical work required. Nine switches are available in each series, with electrical capacity of 10 amp, 120, 240, and 480 v ac. **Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.** K

Circle 738 on Page 19

Telephone-Type Relay

has cup-mounted glass Teflon spring

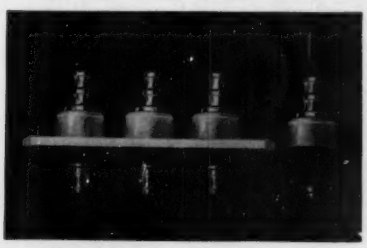
Flexible telephone-type relay can operate 200,000,000 times at a pace of 10 pulses per second. Size of the unit is approximately 2 7/32 x 1 3/32 in. Rugged, cup-mounted glass Teflon spring and armature bushings are incorporated. Unit provides fast make and break for maximum number of circuits. Long coil construction permits use of high-resistance coils. Unit operates on as little as 2 ma. **Phillips Control Corp.**, 59-T W. Washington, Joliet, Ill. I

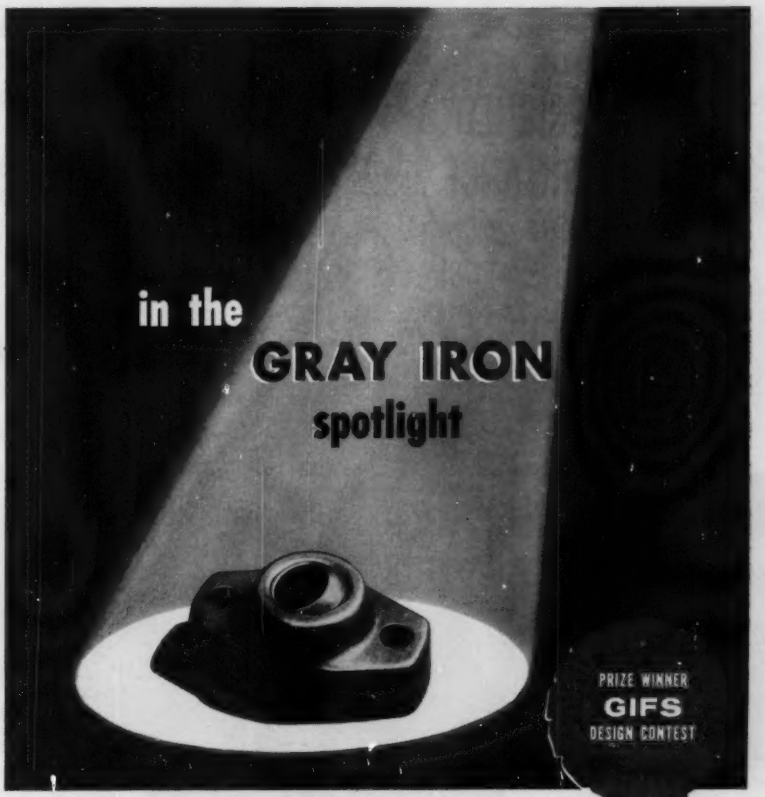
Circle 739 on Page 19

Hermetic Terminals

for intermediate-voltage electronic components

No. 599 nonturning hermetic terminals are available for electronic components such as transformers and capacitors in intermediate (1500





"Ready to go" Gray Iron Casting saves Oliver Corporation 80%

The Oliver Corporation, leading farm implement manufacturer, reduced costs 80% by converting a swivel fastener from a multiple-piece part to a single iron casting. Using gray iron's unique ability to be cast in an intricate shape as one part, *as well as around a movable ball bushing,* Oliver eliminated all assembly and welding operations. The ball is coated with a precise thickness of refractory so that when the iron is cast around it and the refractory removed, the ball is firmly held but free to move. You, too, can eliminate costly in-plant operations. Design your products "ready to go" with your GIFS foundry engineer. Through association with nearly 400 foundries, he has acquired a broad fund of knowledge to help improve your product.

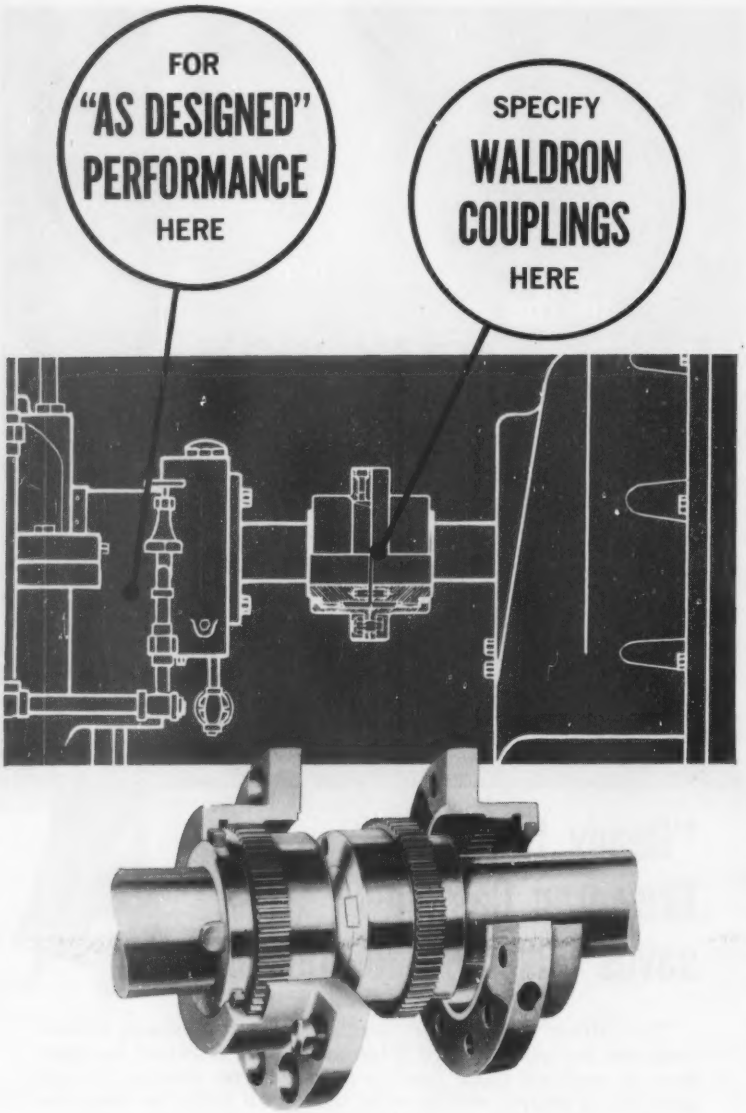
FREE DIRECTORY OF PROGRESSIVE FOUNDRYMEN

Lists modern facilities, techniques and types of iron produced by leading gray iron foundries in your area. For a copy write: Dept. G, Gray Iron Founders' Society, Inc., National City-East Sixth Building, Cleveland 14, Ohio.

Specify Modern GRAY IRON CASTINGS

Made by Informed Foundrymen!

Circle 546 on Page 19



When a lot of time and effort have been put into the design of a driven unit, it makes sense to protect its operating efficiency with a good coupling.

Waldron gear couplings are available in a wide range of standard and special types for any service requirement, to provide complete protection and positive, trouble-free drive.

Deliveries are excellent. Rough bore standard couplings up to 6" sizes, already assembled, can be shipped from stock; others, to meet customers' schedules.

WALDRON Couplings

WALDRON-HARTIG DIVISION
MIDLAND-ROSS CORPORATION
P. O. Box 791 • New Brunswick, N. J.

Circle 547 on Page 19

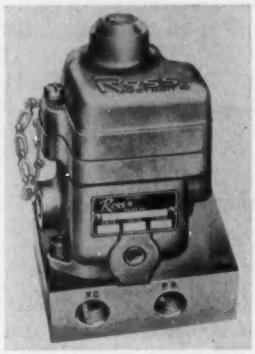
v) voltage range. Single-unit assembly with no loose parts is moderate in cost and is easy to install. **Lundey Associates,** 694 Main St., Waltham, Mass. B

Circle 740 on Page 19

Solenoid Valve

cycles in excess of 1000 cpm

Pacer lightweight solenoid valve has high flow-capacity-to-solenoid size, and cycles in excess of 1000 cpm. It incorporates full 5/32-in. minimal internal orifice, yet requires only 7 w of power. Designed to



JIC specifications, valve has short poppet travel, dust and liquid-tight seal, cast-aluminum body, and integral wiring space. It can be actuated manually and is inoperative if captive cover is removed. Four-way unit shown handles air service range of 15 to 150 psig. Pipe sizes accommodated are $\frac{1}{8}$ and $\frac{1}{4}$ in. **Ross Operating Valve Co.,** 120 E. Golden Gate Ave., Detroit 3, Mich. T

Circle 741 on Page 19

Flexible Connectors

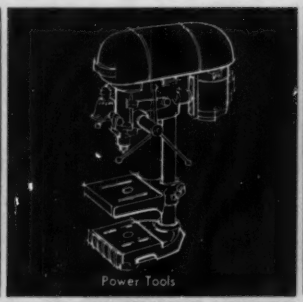
block noise and vibration

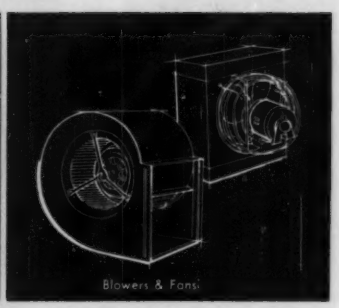
Penflex flexible metallic connectors are available for quick, efficient operation of pump installations, hot-water systems, and steam systems where thermal expansion and vibrations are problems. Applications include correction of pipe misalignment, use as connectors to absorb pipe expansion in steam and hot-water lines, and use on pumps where vibration of unit must be dampened to prevent unwanted noise and vibration from being transmitted along the lines. Con-

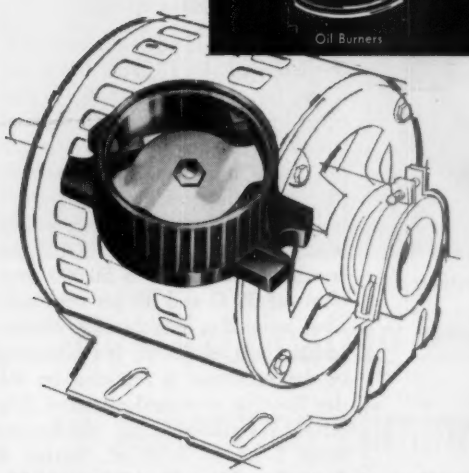
Whatever you manufacture... your motors can be Completely Protected Against Burnouts

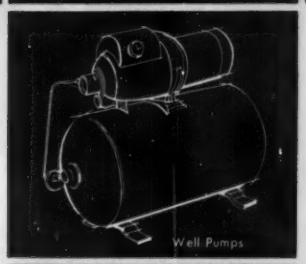
with **KLIXON® TOTAL PROTECTORS**

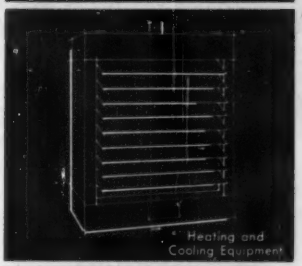
Oil Burners

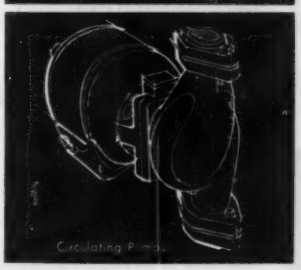

Power Tools


Blowers & Fans




Well Pumps


Heating and Cooling Equipment


Circulating Pumps

Motor burnouts are costly . . . costly to the equipment manufacturer . . . costly to the equipment user. You can safeguard your equipment against motor failures by specifying and using motors with built-in KLIXON Total Protectors.

Here's how you benefit — motors operate at safe maximum output without premature failure . . . motor repairs, replacement and service calls are minimized . . . product reliability is assured . . . customer satisfaction is maintained.

Ask your motor supplier about the advantages of KLIXON Total Protection. The additional cost is low . . . the savings high. Write for Bulletin MOPR4.

Klixon Total Protectors Are Available To Meet Your Exacting Protection Requirements Against The Following Conditions.

- Running overload with or without high ambient or ventilation blocked.
- Locked rotor normal voltage such as caused by mechanical failure or driven load.
- Locked rotor caused by low voltage where decreased torque is insufficient to start load.
- Locked rotor with main winding only in circuit resulting from open circuit start switch or open circuit in reversing switch.
- Locked rotor with start winding only in circuit, such as that resulting from an open main winding circuit or open circuit in reversing switch.
- Running with both start and main windings in the circuit resulting from start switch failure in closed position or low voltage which prevents reaching switch-over speed.

Over 200,000,000 motors are protected against overheating and burning out with KLIXON PROTECTORS.

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TEXAS INSTRUMENTS
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Spencer Products: Klixon® Inherent Overheat Motor Protectors • Motor Starting Relays • Thermostats • Precision Switches • Circuit Breakers

Name your most difficult shaft sealing problem, and you've named the best reason for using a Borg-Warner Mechanical Seal on that shaft.

The real practical value of Borg-Warner Seals is their ability to seal *effectively* under the toughest extremes of temperature and pressure ... for toxic, volatile or corrosive fluids ... and even some abrasive liquids. *Result*—less down time, elimination of leakage and expensive stuffingbox maintenance.

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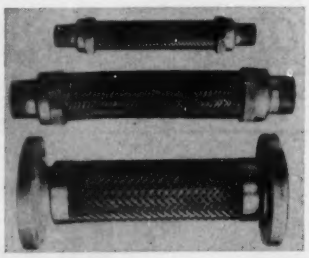


nectors are available in bronze and stainless steel. Bronze units range in size from ½ to 4 in. ID, and stainless steel units from 5 to 12 in. ID. They withstand pressures from 125 to 600 psi, varying with tube ID and material of construction. **Pennsylvania Flexible Metallic Tubing Co.**, 7200 Powers Lane, Philadelphia, Pa. E

Circle 742 on Page 19

Printed-Circuit Laminate

has high impact strength

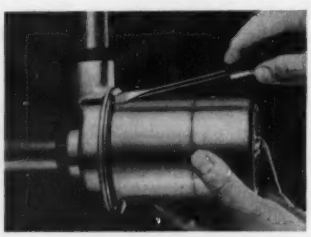
Farlite P-633-GS high-pressure plastic laminate is a paper-base, medium hot punching grade. It features high impact strength, high insulation resistance, low power factor, and high surface resistivity. Minimum flatwise flexural strength is 16,000 psi, with minimum lengthwise tensile strength of 12,400 psi. Insulation resistance is 50,000 megohms at 35 C and 90 per cent relative humidity. Machining characteristics are excellent. No blistering or delamination is reported on solder floating of etched patterns. Material is available in thicknesses from 1/32 to 5/16 in. **Farley & Loetscher Mfg. Co.**, 7th & White St., Dubuque, Iowa. I

Circle 743 on Page 19

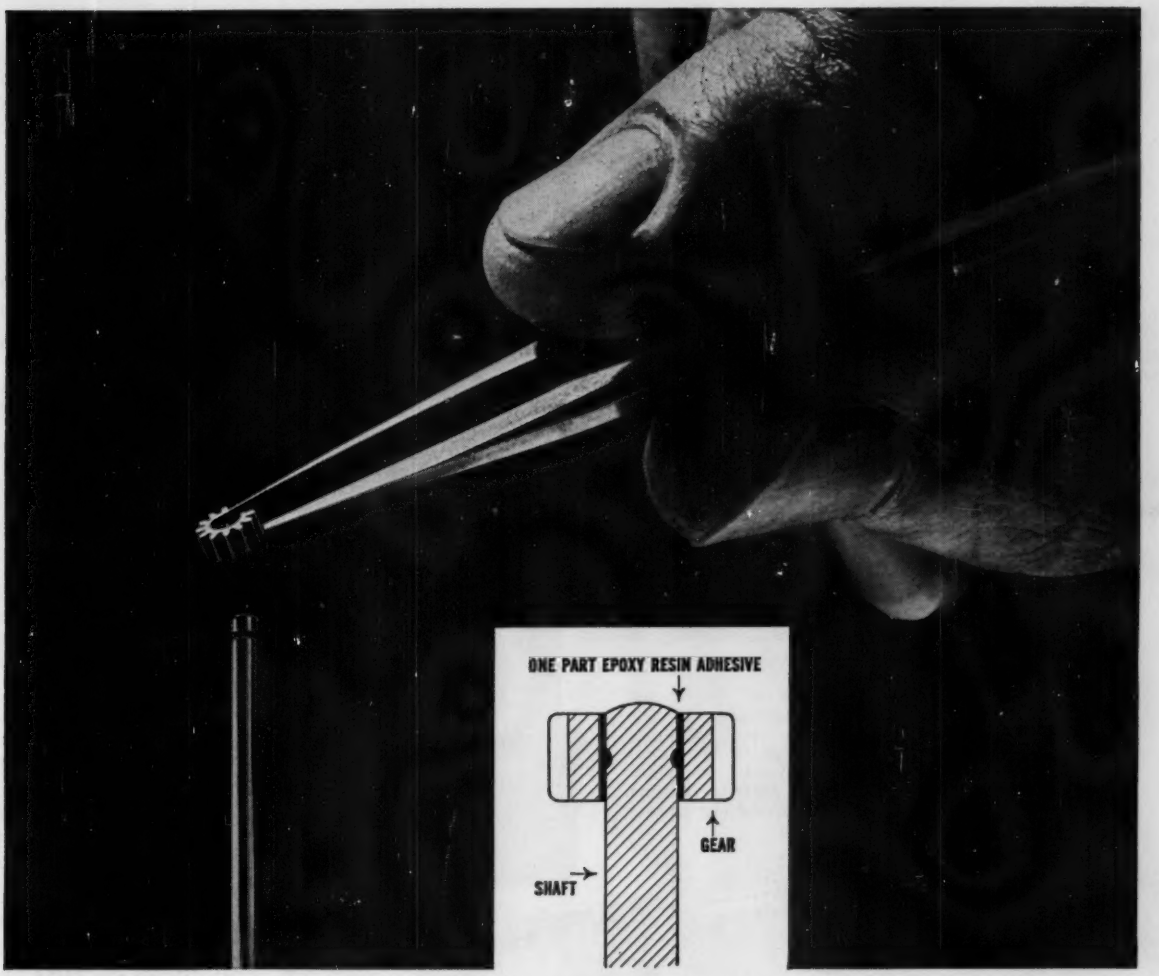
Leakproof Pump

for pressures to 150 psi and temperatures to 220 F

Model 420D compact, leakproof pump for commercial and indus-



Circle 549 on Page 19



How fabricating with SCOTCH-WELD® BRAND Structural Adhesives eliminated 100% inspection step

Timing components now being fabricated with SCOTCH-WELD Adhesive EC-1386 meet precise specifications. The Haydon Division, General Time Corp., Torrington, Conn., is using this one-part epoxy resin base adhesive to bond small pinion gears to rotor shafts in a sub-assembly timing gear operation.

Prior to use of EC-1386, the parts were joined by brazing. But the high heat required affected the material hardness. It also produced shaft distortion, necessitating a 100% inspection step.

Then SCOTCH-WELD Adhesive EC-1386 was used. The high heat previously required was eliminated. With the end of this trouble source, shaft concentricity and material hardness were left unaffected, the 100% inspection eliminated. Close tolerance requirements between shaft and gear were also eliminated because of void-filling properties of the adhesive. A savings of $56.37 per thousand assemblies resulted.

Company after company is discovering how to save money, speed production and eliminate rejects by using SCOTCH-WELD Structural Adhesives in the fabrication of their products. Perhaps these adhesives are at work right now in operations similar to yours. Find out! For free literature without obligation, write today on your company letterhead to: AC&S Division, 3M Company, Dept. SAR-10, St. Paul 6, Minnesota. "SCOTCH-WELD" is a Reg. T.M. of 3M Co.

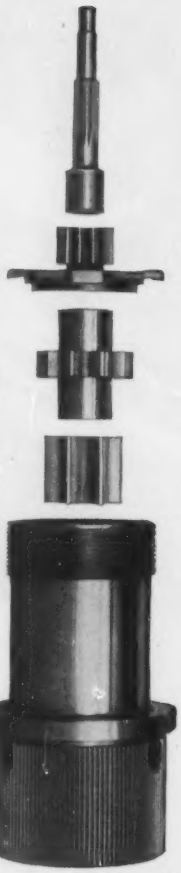
ADHESIVES, COATINGS AND SEALERS DIVISION

MINNESOTA MINING AND MANUFACTURING COMPANY

...WHERE RESEARCH IS THE KEY TO TOMORROW

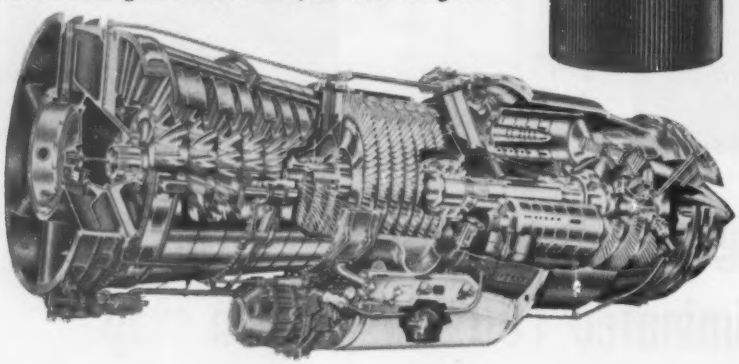
3M COMPANY

PRECISION for top-flight performance!



Rigid PRATT & WHITNEY AIRCRAFT precision requirements spell *performance* . . . top-flight performance. Reason: The future is at stake. And that future can well ride on gear teeth. Since 1940, PRATT & WHITNEY AIRCRAFT gear tolerances have been *Perkins'* standards . . . for commercial gears as well as aircraft. Such precision pays off in longer wear, greater efficiency, lower maintenance cost. That type of precision can pay off for you, too.

Famous PRATT & WHITNEY AIRCRAFT J57 Jet Engine, power plant for Air Force "Snark" guided missile, is geared for both commercial and military performance by *Perkins*. Typical tolerances on *Perkins* gears: .0004 tooth to tooth; .0015 cumulative; .0005 on involute. On spline: .0006 tooth to tooth; .0008 cumulative; .0005 on involute. Most *Perkins* gears are carburized, hardened and ground.



YOURS ON REQUEST Folder showing custom gears Perkins has made (from various materials) for aircraft, automotive, precision instruments, home appliances, portable and machine tools, and other products. Includes Perkins facilities for producing various gear types and sizes. *Write today.*

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MACHINE AND GEAR CO.

Dept. 63 West Springfield, Mass.
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trial use weighs less than 7 lb, yet pumps over 800 gph. It produces heads up to 12 ft. Constructed entirely of corrosion-resistant material, pump provides all advantages of canned pumps. It is suitable for pressures to 150 psi and temperatures to 220 F. Unit is available for operation on either 115 or 220 v, single phase, 50 or 60 cycles. **Dynapump Div., Fostoria Corp.,** P. O. Box 35-3, Huntingdon Valley, Pa. E

Circle 744 on Page 19

General-Purpose Adhesive

has fast grab and long open-bonding time

Low-cost, general-purpose adhesive is suitable for firm bonding of fabrics, leathers, and insulation to woods, metals, and glass. Combination of fast grab and long open-bonding time makes adhesive well suited for brush, spray, or roll-coat application for simple bonding of parts without critical timing. Identified as Rez-N-Glue No. 218, adhesive is a red, high-solids type, reclaim-rubber base, available in 1-qt, 1-gal, and 55-gal quantities. It conforms to requirements of specification MIL-A-101A. **Schwartz Chemical Co.,** 50-01 Second St., Long Island City 1, N. Y. D

Circle 745 on Page 19

Diaphragm Material

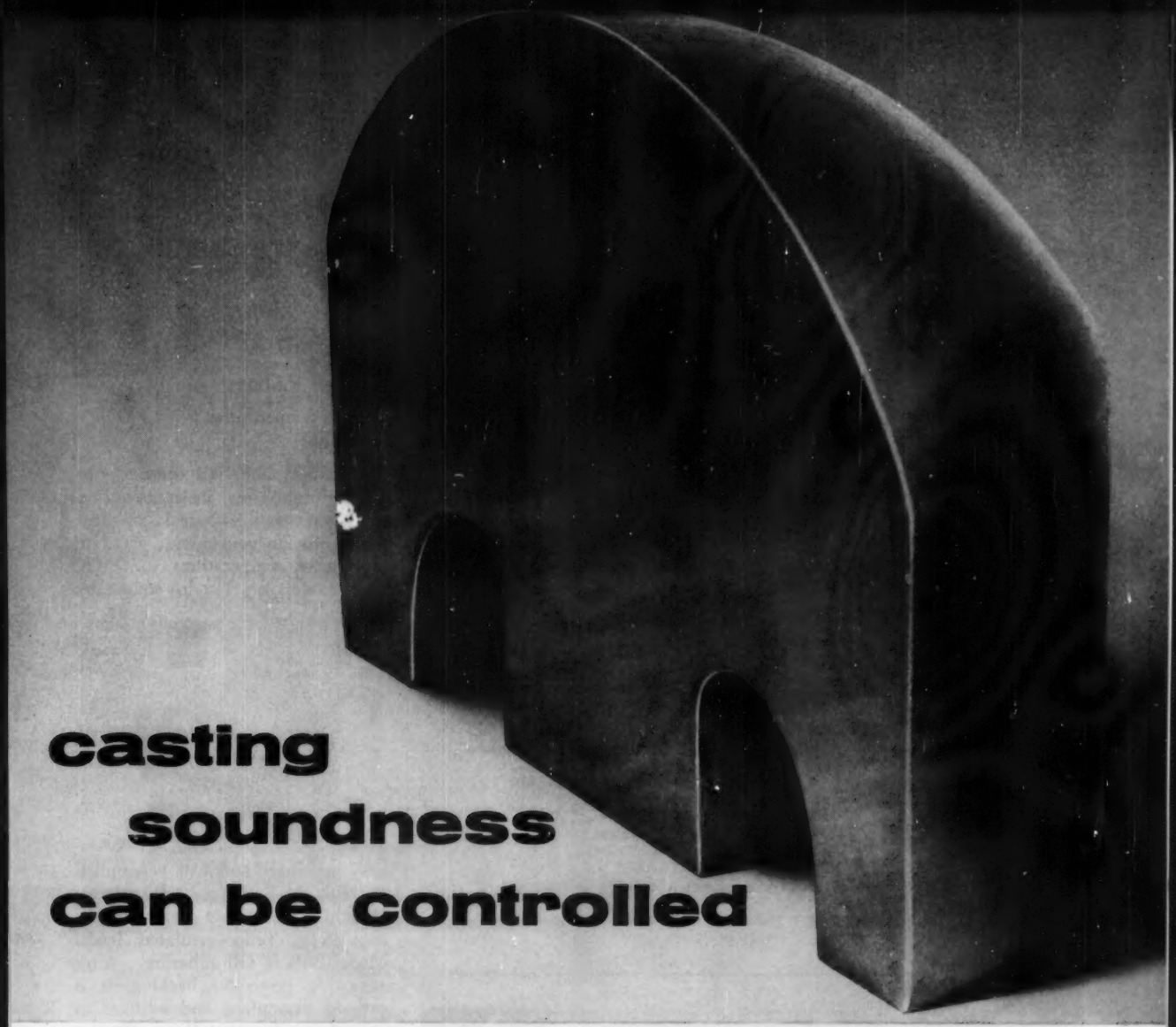
for low-temperature applications

Reevecote 7331 Buna-N coated nylon diaphragm material is available for all types of regulators, air brakes, and other controls exposed to oil, water, gas, and gasoline. It has good resistance to aromatics. Material retains its flexibility characteristics at temperatures to −67 F. It also has antiwicking features, particularly important in controls with an internal vent system, where vent hole is located close to outer edge of diaphragm. With thickness of 0.025 in., material has rated Mullen burst strength of 600 lb and grab tensile strength of 250 x 275 lb. **Reeves Brothers Inc.,** 1071 Avenue of the Americas, New York 18, N. Y. D

Circle 746 on Page 19

Circle 551 on Page 19

Circle 552 on Page 19→



casting soundness can be controlled

Avoid risk of hidden defects . . . specify Meehanite castings

In castings of varying sizes and sections the control of metal structure is of paramount importance in preventing porosity and deviations in physical properties. Meehanite metal's dense, fine grain structure which assures casting solidity . . . free and easy machinability . . . and consistent physical properties regardless of mass or section is achieved by patented manufacturing methods quite unique in metallurgical control.

The uniform soundness of Meehanite castings is predictable in advance . . . in every casting . . . in every group of castings. You can depend on Meehanite to save you time and money in your shop and to enhance your products reputation in the field.

Avoid the risk of hidden defects which result in high machining costs and time loss. Don't take a chance on bargain prices or so-called "equivalents." Specify Meehanite castings and be free from worry. Whatever your casting requirements, there is a nearby Meehanite foundry ready to serve your needs.

For additional facts about Meehanite®, write to the Meehanite Metal Corporation, 714 North Ave., New Rochelle, New York, for your free copy of *Meehanite Means Better Castings.*

MEEHANITE METAL

The American Laundry Machinery Co., Rochester, N. Y.
Atlas Foundry Co., Detroit, Mich.
Banner Iron Works, St. Louis, Mo.
Barnett Foundry & Machine Co., Irvington, N. J.
Casting Service Corp., LaPorte, Indiana and Bridgman, Michigan
Centrifugally Cast Products Div., The Shenango Furnace Co., Dover, Ohio
Compton Foundry, Compton, Calif.
Continental Gin Co., Birmingham, Ala.
The Cooper-Bessemer Corp., Mt. Vernon, Ohio and Grove City, Pa.
Crawford & Doherty Foundry Co., Portland, Ore.
Dayton Casting Co., Dayton, Ohio
Empire Foundry Co., Tulsa, Okla. and Bonham, Texas
Florence Pipe Foundry & Machine Co., Florence, N. J.
Fulton Foundry & Machines Co., Inc., Cleveland, Ohio
General Foundry & Mfg. Co., Flint, Mich.
Georgia Iron Works, Augusta, Ga.
Greenlee Foundries, Inc., Chicago, Ill.
Hamilton Foundry, Inc., Hamilton, Ohio
Johnstone Foundries, Inc., Grove City, Pa.
Kanawha Manufacturing Co., Charleston, W. Va.
Kennedy Van Saun Mfg. & Eng. Corp., Danville, Pa.
Lincoln Foundry Corp., Los Angeles, Calif.
Nordberg Manufacturing Co., Milwaukee, Wis. and St. Louis, Mo.
Oil City Iron Works, Corsicana, Texas
Palmyra Foundry Co., Inc., Palmyra, N. J.
The Henry Perkins Co., Bridgewater, Mass.
Pohlman Foundry Co., Inc., Buffalo, N. Y.
Rosedale Foundry & Machine Co., Pittsburgh, Pa.
Ross-Meehan Foundries, Chattanooga, Tenn.
Sonith Foundries of FMC, Indianapolis, Ind.
Standard Foundry Co., Worcester, Mass.
The Stearns-Roger Mfg. Co., Denver, Colo.
Vulcan Foundry Co., Oakland, Calif.
Washington Iron Works, Seattle, Wash.
Dorr-Oliver-Long, Ltd., Orillia, Ontario
Hartley Foundry Div., London Concrete Machinery Co., Ltd., Brantford, Ontario
Otis Elevator Co., Ltd., Hamilton, Ontario

MEEHANITE METAL CORPORATION, NEW ROCHELLE, NEW YORK

One word explains the popularity of these switches...

Dependability!

Denison LOXSWITCH Limit Switches operate with the dependability of Old Faithful. Oil- and dust-tight features, superior electrical characteristics and mechanical design result in three to five times longer life than comparable switches.

L100W HEAVY DUTY LIMIT SWITCH

- 45 CIRCUIT ARRANGEMENTS.
- LONGEST CONTACT LIFE due to lowest impact of 2.5 grams and minimum "bounce".
- WATER-, DUST- AND OIL-TIGHT, NEMA 12.
- ONLY FOUR MOVING PARTS. Longer life, easier to maintain.
- 70° SAFETY OVERTRAVEL without use of extra springs or cams.
- OVER 150 LEVER STYLES.

MODEL M PRECISION LIMIT SWITCH

- LONG MECHANICAL LIFE nylon latch mechanism.
- 600 VOLT INDUSTRIAL CONTROL RATING.
- COMPLETELY ISOLATED CIRCUITS.
- 6° TRIP DIFFERENTIAL, 50° overtravel in both directions.
- PRECISION REPEATABILITY ± .001".
- WATER-, OIL-, DUST-TIGHT – NEMA 12.
- FULLY INTERCHANGEABLE with thousands of existing layouts.

BOTH MODELS AVAILABLE WITH PLUG-IN CONVENIENCE

Write for literature describing our complete line.

Address R. B. DENISON MFG. CO., 386 Broadway, Bedford, Ohio

DENISON LOXSWITCH

*Wire with **LOXSWITCH** and you wire for good!*

ENGINEERING DEPARTMENT

EQUIPMENT

Thermal Ribbons

sense temperatures to 500 F

Models S8A and S8B thermal ribbons, for use in instrumentation and temperature-control applications, provide convenient, accurate sensing of temperatures to 500 F. Both models are 1¼ in. square by

0.05 in. thick, and can be applied to both flat and curved surfaces. Weight is less than 4 grams, including 36-in. Teflon-insulated leads. Model S8B is self-adhering. After removing protective backing, it is pressed into place and adheres to any clean, dry, metallic surface as well as to many other materials. Model S8A is furnished with pressure-sensitive installation tape or can be cemented in place or held by mechanical means. Both types are calibrated within ±1 per cent. They are shipped with calibration curve for operating range from −76 to +500 F. **Minco Products Inc.**, 740 Washington Ave. N., Minneapolis 1, Minn. H

Circle 747 on Page 19

Portable Recorder

for strain gage or thermocouple monitoring

Low-cost portable potentiometer recorder with 6-in. chart is available for applications such as strain-gage or thermocouple monitoring. Furnished for either portable or rack-mounting use, unit design al-

IF A *MINIATURE* OR *INSTRUMENT* BEARING IS NEEDED . . .

NEW HAMPSHIRE

. . . IS THE *SOURCE!*

To meet the exacting requirements of your applications, New Hampshire maintains a full line of miniature and instrument bearings for research and development, prototypes and replacements at all regional offices. (Production quantities are shipped direct from our main plant.) NHBB sales engineers are always on call to discuss your particular needs and make specific recommendations.

RETAINER BEARINGS

This is one of the most frequently specified types for instrument applications. Available with newly designed crown retainers. This design permits even ball spacing, low torque, and most consistent performance. *Over 150 standard types and sizes are listed in our Design Manual.*

SIZES

(Available in a wide selection of combinations within the following ranges)

	BORE	O.D.	WIDTH
Min.	.0469	.1562	.0625
Max.	.3125	.6250	.1960

EXTENDED INNER RINGS . . . available on all above types

FULL BEARINGS

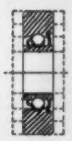
Full bearing (Available plain or flanged)

Specified for applications requiring maximum radial load capacity. Not suited to low torque requirements. *Over 21 standard types and sizes.*

SIZES

	BORE	O.D.	WIDTH
Min.	.0250	.1000	.0312
Max.	.3125	.5000	.1562

UP and WAFER BEARINGS



A wafer bearing compared with standard equivalent

Expressly designed for use in synchros, servos, small motors, potentiometers, and gear trains. Widths are significantly narrower than standard to allow more room for rotors and stators. *Available in 16 types and sizes.*

SIZES:	BORE	O.D.	WIDTH
Min.	.0550	.1875	.047
Max.	.1875	.4375	.1094

QUALITY PERFORMANCE . . .

is in direct relation to quality of production. *All New Hampshire bearings* are made to ABEC-7 tolerances or better. The result is *improved running qualities* for all users . . . at no extra cost! In addition, rigid quality control during manufacture and continuing research enables New Hampshire to maintain leadership in our field . . . to supply you with the finest bearings for your needs at the lowest cost.

IMMEDIATE DELIVERIES FROM STOCK . . .

(For research & development, prototypes, and replacements) are made from our three regional offices as well as the main plant. Bearing specialists are on hand to help you plan and specify. Call your nearest office collect for fast service.

NEW HAMPSHIRE BALL BEARINGS, INC.

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566 Northwest Highway
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VAnderbilt 7-6646 TWX: 1642U

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NEW DESIGN MANUAL

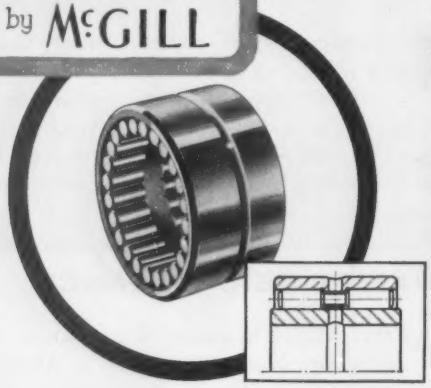
Newly revised and expanded, this authoritative publication is a guide to designing around, specifying and purchasing of miniature and instrument ball bearings. Comprehensive general information, catalog data, and engineering bulletins are included in the 100-plus pages. A personally registered copy is available to qualified engineers, draftsmen, and purchasing departments.

For your free Design and Purchasing Manual, write or call any New Hampshire Office.

NEW HAMPSHIRE BALL BEARINGS, INC.

PETERBOROUGH, N. H.

BEARING TIPS
by McGILL



GUIDEROL®

BEARINGS SOLVE SPECIFIC DESIGN PROBLEMS

with high capacity in small radial space, precision efficiency and "sealed in" lubrication

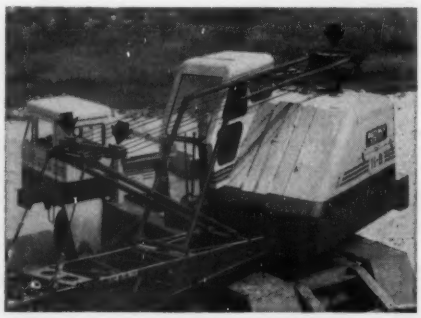
McGILL GUIDEROL Bearings combine the higher inherent capacity of full complement needle roller bearings with "center-guided" roller control. GUIDEROL bearing construction encourages space and cost saving design of shaft and housing components. For a given shaft of 1" a GUIDEROL bearing provides 23% more capacity in ⅜" less housing space than a typical cylindrical roller bearing. A comparable ball bearing uses almost an inch larger OD for 1500# less capacity.

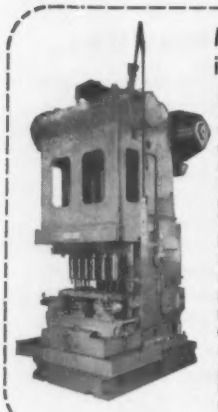
Use the Sealed SGR series to protect GUIDEROL bearing efficiency when contamination exists. Avoid frequent re-lubrications.

GUIDEROL bearings are available with or without separable inner ring. Shaft sizes: ⅜" to 9¼". Capacities to 128,670 lbs. (at 100 RPM).

Bucyrus-Erie Cuts Lubrication from Daily to Monthly with Sealed Guiderol Bearings

BUCYRUS-ERIE CO. has incorporated the advantages of GUIDEROL GR-28RSS, sealed bearings in their 11-B TRANSIT CRANE-EXCAVATOR. The bearings serve as mountings for sheaves in the 11-B boom suspension which is a wire rope system running from a powered cable drum over the sheaves. The GUIDEROL bearings decrease friction and provide a jerk-free lowering and raising of the boom. In addition, they have increased periods between lubrication from once a day to once a month under normal operation. BUCYRUS-ERIE also cites ease of assembly due to holding to close manufacturing tolerances as an additional benefit. Loads on these bearings are approximately 10,000 lbs.; speeds — 56 RPM. Bearings are used in both horizontal and vertical mountings.



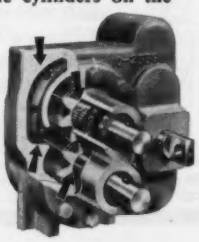


Moline Tool Co. Get High Radial Load in Minimum Space

Each of the six spindles of the MOLINE Model 116U hydraulic rail feed, universal joint type drilling machine has two GUIDEROL upper bearings and two GUIDEROL lower bearings. The GUIDEROL bearings replaced bronze sleeve bearings used in previous design of the machine. The GUIDEROL bearings were selected for their ability to get the highest possible radial load in minimum space and still retain the advantages of a precision anti-friction bearing. Vertically mounted, the bearings are lubricated by drip feed oil from the upper drive unit. The unsealed GUIDEROL bearings with open ends permit a free flow and the roller retaining ring acts as an oil ring to pick up and distribute the lubricant.

Guiderol® Bearings Take Heavy Loads of High Volume Hydraulic Pump Service.

GALION ALLSTEEL BODY COMPANY'S combination high volume roller bearing pump and spool valve has been developed to furnish the large volume of high pressure oil needed for fast dumping with Duo-scopic hoists. These pumps operate the hydraulic cylinders on the complete line of Galion trailer dump bodies. Four small GUIDEROL bearings easily accept loads of 3,500 pounds on the driving shaft and 4,500 pounds on the driven shaft. They provide maximum capacity in small radial space with a full complement of race width rollers. These center guided rollers help insure the precision performance required to increase pump capacity to 1,450 PSI at 1,000 RPM.



engineered electrical products

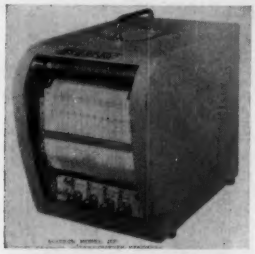
McGILL®

precision needle roller bearings

Send for Free Bearing Catalog No. 52A for complete Data.

MULTIROL-GUIDEROL-CAMROL-CAGEROL

McGILL MANUFACTURING COMPANY, INC., BEARING DIV., 200 N. LAFAYETTE ST., VALPARAISO, INDIANA



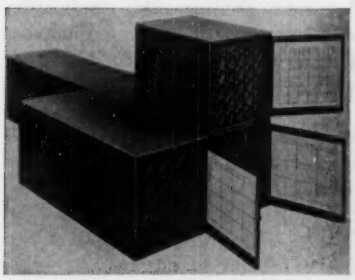
lows up to four recording channels to be mounted in a 19-in. wide rack. With selectable 9 to 120-mv span, gearshift selection of chart speeds, 0.8-sec balance time, and ¼ per cent sensitivity, unit provides extreme versatility. **Systron Corp.**, 950 Galindo St., Concord, Calif. M

Circle 748 on Page 19

Roll Files

are now available in 24 sizes

Staktube roll files for rolled prints, charts, maps, and drawings are available in three tube diameters and eight tube lengths. The 15 5/16-in. square roll files are heavy-gage steel with hard-baked gray enamel finish. New tube sizes include a 16-tube, 3⅜-in. ID size, in addition to 36-tube, 2¼-in. ID and 9-tube, 4⅜-in. ID sizes. Lengths range from 18 to 60 in. Units can be



placed on end or stacked and interlocked to any height. **Stacor Equipment Co.**, 295 Emmet St., Newark 5, N. J. D

Circle 749 on Page 19

Magnetic Tape Transport

has transfer rate of 400,000 characters per sec

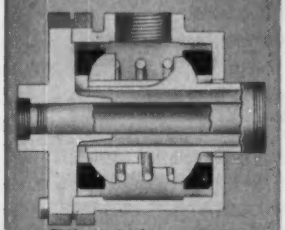
Redesigned Model 906 magnetic tape transport provides 400,000 character per sec transfer rate, achieved with complete program freedom at 120 ips with 10½-in. reels of 1 [illegible]. wide tape and 16 chan-

You can depend on

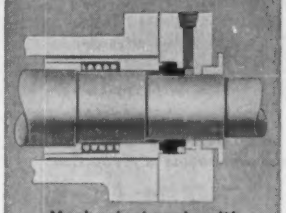
PY4

Morganite

SEALS



PY4 seal rings operate with highest efficiency in this rotary pressure joint carrying steam-condensate.



Mechanical seals with Morganite PY4 noses provide an extra measure of dependability in this stuffing box assembly.

Application tested for all sealing requirements

Service-proven on toughest assignments

LINK PY4 GRADE of self-lubricating MORGANITE is the engineer-preferred seal material for every application where premium performance is a "must." Actual service records compiled on PY4 Seals in all types of rigorous service, prove that this super-rugged material can take punishment! PY4 Seals function with highest efficiency in the presence of grease, searching liquids, corrosives, high pressures and high temperature. Install Morganite LINK PY4 for longer seal life . . . reduce down-time and save on seal replacement costs.

AVAILABLE WORLDWIDE—Send drawings and operating data for a recommendation on your specific seal requirements.

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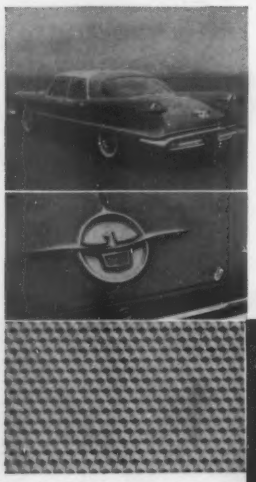
Manufacturers of Fine Carbon Graphite Products including Mechanical Carbons, Motor and Generator Brushes, Carbon Piles, Current Collectors and Electrical Contacts . . . Distributors of 99.7% Pure Al_2O_3 Tubes and Crucibles

Circle 556 on Page 19



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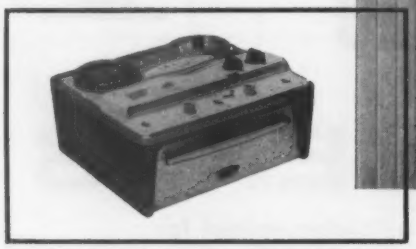
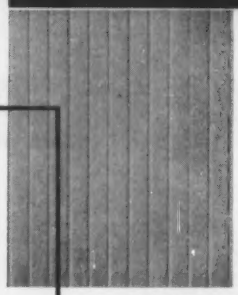
QUEST for QUALITY
discerning
DESIGN ENGINEERS
choose

ARDMORE
TEXTURED
METALS

Chrysler-Imperial rear deck trim
Dunhill Texture





Webcor Royalite Tape Recorder
Trent Texture

Quality (a much overused . . . and often abused word) can be as elusive as Ponce de Leon's fabled elixir. Fortunately, today's design engineer is endowed with a keen **sales sense** which enables him to instinctively select materials that enhance the value of his product and make it sell. Two noteworthy examples of distinctive quality design are shown above. Both the luxurious Chrysler Imperial and the Webcor Royalite Tape Recorder utilize Ardmore Textured Metals.

These exciting textures in metal are the stock in trade of men with imagination who are designing the products of today and tomorrow. On the brink of a new decade — "The Exploding Sixties", design engineers are being challenged to devise better, more durable, more attractive products to meet the demand of the forecasted explosion in our population, economy and scientific horizons. New materials such as Ardmore Textured Metals will play an important part in satisfying these ever-increasing demands because they provide the perceptive designer, greater versatility . . . the manufacturer, greater profit potential and . . . the consumer, greater value.

Ardmore representatives are oriented to your problems and can furnish reliable assistance in materials selection. Prompt attentive service and the latest high-speed equipment insure dependable deliveries. Eight exciting new Ardmore Textures are available in **all** metals — solid or perforated and a multitude of finishes in sheets up to 52" in width, or continuous coils to 48" width. Visualize Ardmore Textured Metals into your product designs — **match the magnitude of your markets with imagination.**

Send today for this new 8 page brochure which describes in detail all of the textures and finishes available together with photos of production applications in all industries.

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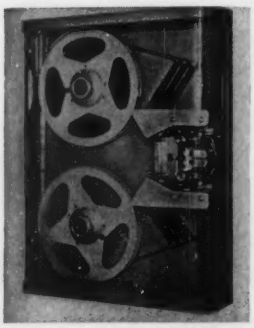


nels of high-density recording system. Design includes redundant guide system and improved braking mechanism, both contributing to minimum tape wear. Nonadjustable, fully interchangeable head mounting assures precise tape alignment at all times. Rack-mounting dimensions are 24½ in. in height and 18 in. in depth. Solid-state electronics, supported by logically arranged plug-in boards, provide servo drive and control. **Potter Instrument Co. Inc.**, Sunnyside Blvd., Plainview, L. I., N. Y. D

Circle 750 on Page 19

Transformer Amplifier

provides oscillographic indication and recording

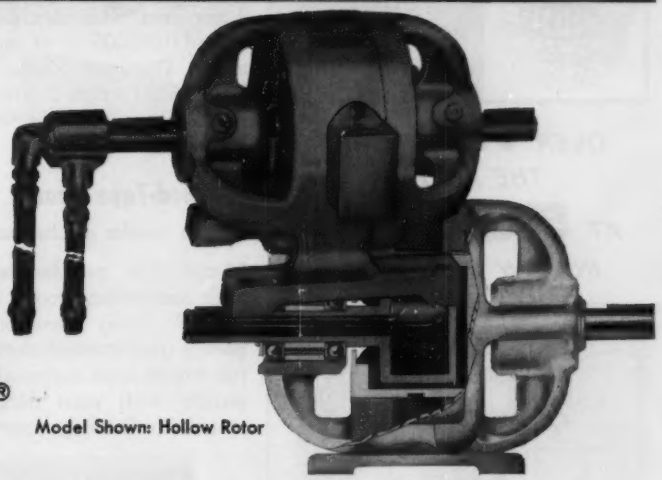
Accurate oscillographic indication and recording of linear motion, acceleration, force, pressure, and other quantities measurable by differential transformer transducers, is achieved with Model 401C differential transformer amplifier. Output is suitable for viewing on cathode-ray oscilloscopes or for direct drive of Brush, Visicorder, and similar pen or light-beam galvanometer recorders. Unit features internal excitation supply, self-checking features which eliminate drift errors, and five calibrated sensitivity ranges which cover all usual scientific and industrial requirements. Frequency response is flat from zero to 200 cps

NEW... for high slip applications

VICKERS®

WATER-COOLED MAGNECLUTCH®

Dry Magnetic Particle Clutch



Model Shown: Hollow Rotor

for cycling, tension and speed control, braking...

The need for clutches (and brakes) for critical slip applications is now met by Vickers new water-cooled MAGNECLUTCHES. Whether for tension control of web materials ranging from tissue paper to strip steel, for cycling, start-stop or braking operation or wherever smooth and positive torque or speed control is required, the MAGNECLUTCH provides unexcelled performance over a wide range of operating and slip speeds.

With the exception of the salient feature of high heat dissipation ability, Vickers water-cooled units are identical to air-cooled MAGNECLUTCHES . . . and have all the unique and outstanding characteristics that are inherent in all Vickers dry magnetic particle units:

- *High heat dissipation capacity.*
- *Clutching or braking application.*
- *Complete torque controllability.*
- *Torque capacities from 10 lb-ft to 200 lb-ft.*
- *Unlimited service life (no wear on clutch surfaces).*
- *Full torque at zero slip.*
- *Torque independent of speed.*
- *Provide precise tension control with no material breakage and high productivity, eliminate operator error.*

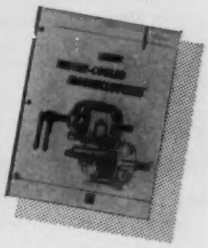
EPA6100-3

SPECIFICATIONS

CLUTCH CATALOG NO.	MOUNTING	RATED TORQUE SIZE	[1]AVERAGE CONTINUOUS HEAT DISSIPATION CAPACITY, INITIAL ROTOR SPEED 1800 RPM (WATTS)	NON-EXCITED DRAG TORQUE	[2]D. C. COIL CURRENT FOR RATED TORQUE (98V DC)	[3]MAXIMUM OPERATING SPEED (RPM)	WEIGHT (LBS.)
6-2-2 BR	Foot	10 lb-ft	200W	0.2 lb-ft	0.23 amp	2300 rpm	29
6-2-2 WC	Foot	10 lb-ft	400W	0.2 lb-ft	0.23 amp	2300 rpm	28
6-2-3 BR	Foot	45 lb-ft	630W	0.6 lb-ft	0.51 amp	2300 rpm	74
6-2-3 WC	Foot	45 lb-ft	1260W	0.6 lb-ft	0.51 amp	2300 rpm	72
6-2-4 BR	Foot	100 lb-ft	750W	1.0 lb-ft	0.46 amp	2300 rpm	124
6-2-4 WC	Foot	100 lb-ft	2250W	1.0 ft-lb	0.46 amp	2300 rpm	122
6-2-6 BR	Foot	200 lb-ft	860W	2.0 lb-ft	0.92 amp	2300 rpm	233
6-2-6 WC	Foot	200 lb-ft	1780W	2.0 lb-ft	0.92 amp	2300 rpm	230

[1] In applications involving repetitive braking, high inertias, etc., it is recommended that our engineers review your data.
[2] Coils For Other Voltages Wound to Order.
[3] Higher Operating Speeds Attainable With Special Fittings.

WRITE TODAY
for Bulletin EPD 6126-3



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ELECTRIC PRODUCTS DIVISION

1881 LOCUST STREET / SAINT LOUIS 3, MISSOURI

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CHICAGO *Samuel Harris & Company—FRanklin 2-7272*
Vickers Inc., EPD—JUniper 8-2125
CLEVELAND *Vickers Inc., EPD—EDison 3-1355*
DALLAS *General Power Equipment Company—EMerson 8-4655*
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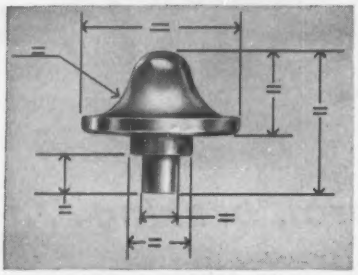
IT PAYS TO HAVE HUBBELL GOOD CONNECTIONS

Manufacturers of Cold Headed Fasteners Since 1888

OVER **10** TIMES THE RATE AT **50%** SAVING IN RAW MATERIAL



Another example of how Hubbell Cold Heading produces Better Parts at Faster Speeds, at Lower Cost

THE PART:
Click Button

THE MATERIAL:
Brass

THE METHOD:
Hubbell cold heading in place of screw machining.

THE RESULT:
This brass click button was machined previously from bar stock, involving several different operations that removed nearly 50% of the total weight of the original stock . . . a wasteful, time-consuming, costly process.

Hubbell now produces essentially the same part at tremendous savings in time and material cost.

a. Production is increased from the original rate of 5.5 pcs. p.m. to cold heading rate of 60 pcs. p.m.

b. Labor, overhead and material cost has been reduced 36%.

c. The finished part is stronger, more accurate, with greater uniformity.

Hubbell Cold Heading may provide equally dramatic results for you. Whether it is presently cold headed or not, send blueprint of part or sample for analysis and estimate.

HARVEY HUBBELL, Inc. *Machine Screw Dept.*
Bridgeport 2, Connecticut

Kindly estimate on the enclosed sample (blueprint) Quantity _____

Name _____
Title _____
Company _____
Address _____

Circle 559 on Page 19

and useful to 500 cps. Accuracy is 2 per cent with maximum resolution of 0.000005 in. of core displacement. **Daytronic Corp.**, 225 S. Jefferson St., Dayton 2, Ohio. G

Circle 751 on Page 19

Punched-Tape Reader

with spooler mechanism

Model 909 punched-tape reader with companion spooler mechanism (Model 3299) incorporates completely transistorized electronic readout system with output signals compatible with most data-processing systems. Reading speeds to 200

characters per sec are possible with spooler, which accommodates paper or Mylar tape to 1-in. wide on 8-in. diam reels. Without spooler, Model 909 reads at rates to 1000 characters per sec and stops on a "stop" character. **Potter Instrument Co. Inc.**, Sunnyside Boulevard, Plainview, L. I., N. Y. D

Circle 752 on Page 19

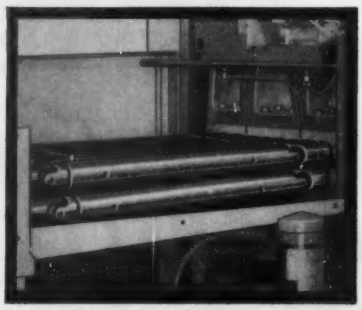
Double Eraser

is pen-sized unit

Twin-Jet eraser consists of a refillable holder of clear plastic which contains two erasers inserted end-to-end. One is red rubber for erasing pencil and for cleaning; the other is gray rubber for erasing ink, typing, and business-machine writing. Each eraser is over 2 in. in length, and length of eraser extending from end of holder can be regulated by unscrewing nib at either end and pushing eraser outward with twisting motion. Unit is about the size of a ball-point pen and has a pocket clip attached. **Weldon Roberts Rubber Co.**, 365 Sixth Ave., Newark 7, N. J. D

Circle 753 on Page 19

HOW CURTIS SOLVED A CLOSE CENTER-TO-CENTER PROBLEM



The close center-to-center spacing of these drive spindles on a Sutton-Maust Precision Backed-up Roller Leveler created a tough problem for its manufacturer. He needed a universal joint strong enough to stand up under heavy rolling mill conditions, yet small enough to operate at such close quarters.

The answer was a Curtis universal joint! The maximum load carrying capacity and minimum torsional deflection of the Curtis joint was found to be completely satisfactory. And Curtis' famous Telltale Lock Ring construction permits quick disassembly for easier maintenance.

This is just one of the many power transmission problems solved by Curtis universal joints — size for size the *strongest* universal joints designed for industry. Selected materials, precision engineering, and 40 years' experience manufacturing universal joints exclusively make them that way.

WRITE FOR THE NEW CURTIS CATALOG, JUST PUBLISHED

14 sizes always in stock ⅜" to 4" O.D.

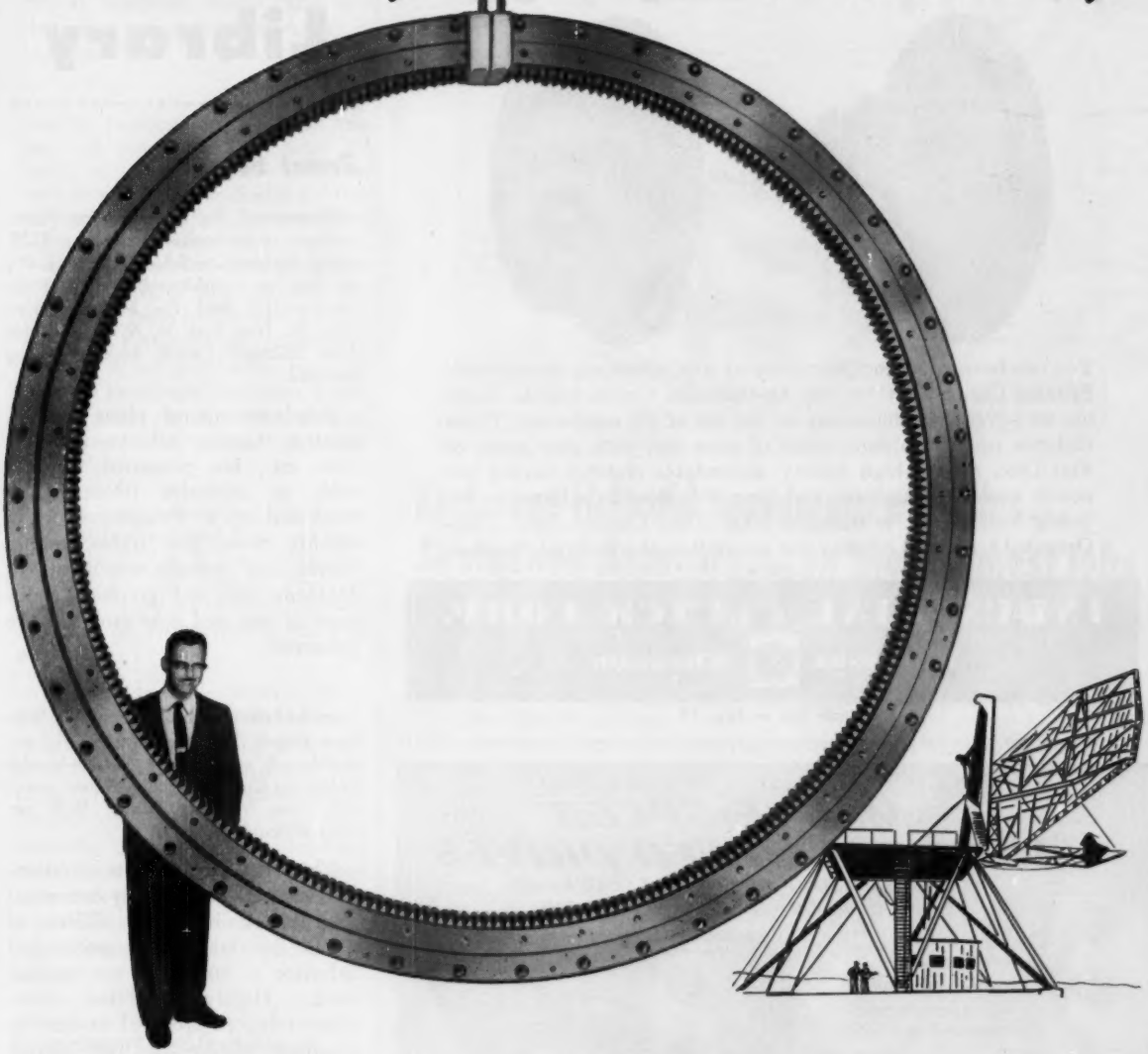
Not sold through distributors. Write direct for free engineering data and price list.

TRADE MARK **CURTIS**

UNIVERSAL JOINT CO., INC.
51 Birnie Ave., Springfield, Mass.
As near to you as your telephone

Circle 560 on Page 19

World's Largest Roller Bearing



Another First for the MESSINGER "X"

Nearly 14 feet in diameter, this Messinger "X" Bearing will play a vital part in the Nation's continental control and warning system. Tests for accuracy in the finished bearing proved that diameters were held to tolerances of .0014", and that the internal gear was accurate within 20 arc seconds. Assurance of long, trouble-free service, with sustained precision, under extremes of operating conditions, was established by performance records of the "X" Bearing in many similar applications and in a wide variety of industrial installations.

Designing a new product? Send now for a Messinger Engineer-Representative to explain the advantages of the versatile "X" Bearing.

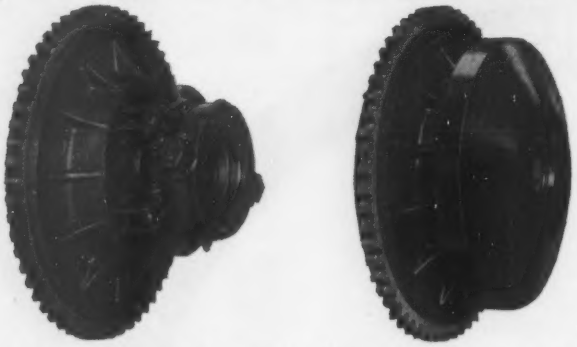
MESSINGER BEARINGS, Inc.

ROLLER AND BALL BEARINGS — *FEATHERWEIGHT TO HEAVYWEIGHT*

D STREET ABOVE ERIE AVE. • PHILADELPHIA 24, PA.

"Smoothing Industry's Pathway for Nearly Half a Century"

Make Your Choice Of Clutch While Your Equipment Is In The Design Stage . . .



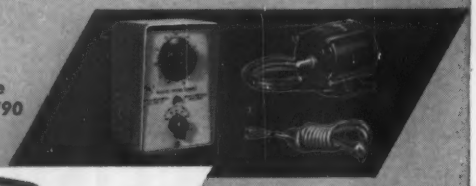
You can have your machine equipped with either our Over-Center Friction Clutch (left) or our Air-Operated Clutch (right). Each has its advantages depending on the use of the equipment. These clutches come in a wide range of sizes and with gear tooth or Flex-Disc. All are high quality, dependable clutches having low power losses, low upkeep, and long life. Readily adjustable for lining wear. Send for bulletins 5009 (Over-Center), 5011 (Air-Operated), or 5012 briefing our entire line of industrial clutches.

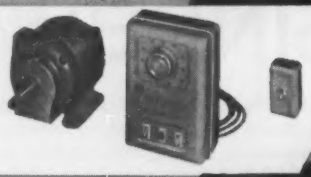
INDUSTRIAL CLUTCH CORP.
Waukesha Wisconsin

Circle 562 on Page 19

FOR INSTANT SMOOTH STEPLESS CONTROL
MAGNE-SPEED VARIABLE SPEED DRIVES
CONSTANT TORQUE OVER ENTIRE SPEED RANGE
RANGE OF ADJUSTMENT ZERO TO FULL SPEED

JUNIOR:
⅛ to 1/100 HP
40:1 speed range
request bulletin S-790





SIZE I:
¼, ⅓ and ½ HP
50:1 speed range
request bulletin S-580

SIZE II:
¾, 1 and 1½ HP
50:1 speed range
request bulletin S-580

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THE ENGINEER'S Library

Recent Books

Kinematics. *By Virgil Moring Faires, professor of mechanical engineering, U. S. Naval Postgraduate School; 468 pages, 6¼ by 9½ in., clothbound; published by McGraw-Hill Book Co. Inc., 330 West 42nd St., New York 36, N. Y.; available from* MACHINE DESIGN, *$8.50 per copy postpaid.*

Fundamentals of plane motion, relative velocity, relative acceleration, etc., are presented together with an extensive treatment of cams and gears. Procedures for designing cams, gear trains, rolling curves, and linkages are discussed. Mathematical and graphical solutions of cam and gear problems are presented.

An Introduction to Plasticity. *By William Prager, 168 pages, 6¼ by 9¼ in., clothbound; published by Addison-Wesley Publishing Co. Inc., Reading, Mass.; available from* MACHINE DESIGN, *$9.50 per copy postpaid.*

This book supplements traditional texts that are primarily concerned with elastic behavior. Effects of plastic deformations on mechanical behavior of structures are emphasized. Highly simplified stress-strain relations are used to describe idealized rigid-plastic or elastic-plastic behavior. Forming processes such as rolling, extruding, and drawing are discussed.

Association Publications

Proceedings of the Fourth Midwestern Conference on Solid Mechanics. *530 pages, 6 by 8¾ in., clothbound; available from Engineering Institutes, University of Texas, Austin, Texas; $12.50 per copy.*

Stress analysis and vibrations, vibrations and dynamics, thermal stresses, and wave propagation were general areas of discussion. Some specific topics covered in the 29 papers are shell theory, fracture arrest by riveted stiffeners, collapse

load of a spherical cap, natural frequencies of vibration of simply supported sandwich beams, and spin dynamics of a thrusting rocket in vacuum.

ASTM Standards on Petroleum Products and Lubricants. 1230 *pages, 6¼ by 9¼ in., clothbound; published by and available from American Society for Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.;* $9.00 *per copy.*

This 1959 edition contains almost 200 standards, of which 45 are new, revised, or have had a recent status change. Presented in convenient form is a comprehensive coverage of crude petroleum, naphthas, lubricating oils, cutting oils, greases, waxes, and other related materials.

ASTM Specifications for Coated and Uncoated Iron and Steel Sheet and Strip. 148 *pages, 6¼ by 9½ in., clothbound; published by and available from the American Society for Testing Materials,* 1916 *Race St., Philadelphia* 3, *Pa.;* $3.00 *per copy.*

This publication presents in a convenient form the ASTM standards relating to sheet and strip steel materials, both metallic-coated and plain. There are 21 standards in the volume including 11 for sheet steel and strip, 3 for metallic-coated steel sheet, 2 for wrought-iron sheet, and 1 for slab zinc. In addition there are 4 methods of test for weight of coating, composition, and mechanical testing.

Government Publications

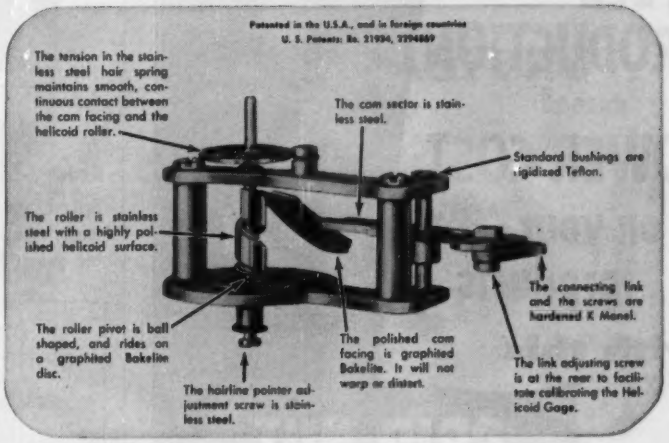
OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 151750. The Corrosivities of Plastics and Rubbers. By H. A. Perry Jr., A. M. Chreitzberg, I. Silver, and H. E. Mathews Jr., U. S. Naval Ordnance Laboratory; 41 pages, 8 by 10½ in., paperbound, side-stapled; $1.25 per copy.

Tests were conducted with contact between metal and plastic or rubber and with the materials separated but within a closed system. Metals tested were steel, copper, brass, aluminum, silver, and solder. Detection and extraction of electrolytes are described. A few case histories are discussed.

PB 151900. Materials in Space Environment: Proceedings of the Fifth Sagamore Ordnance Materials Research Conference. 276 pages, 8½ by 11 in., paperbound; $4.00 per copy.

Presented are problems of materials in the space environments encountered by space vehicles or orbiting satellites. Eighteen papers cover vehicle requirements, physics of space vacuum, thermal problems, effects of radiation, meteorites and cosmic dust, and implications of space environment for material development.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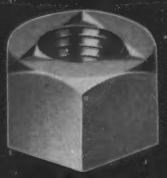

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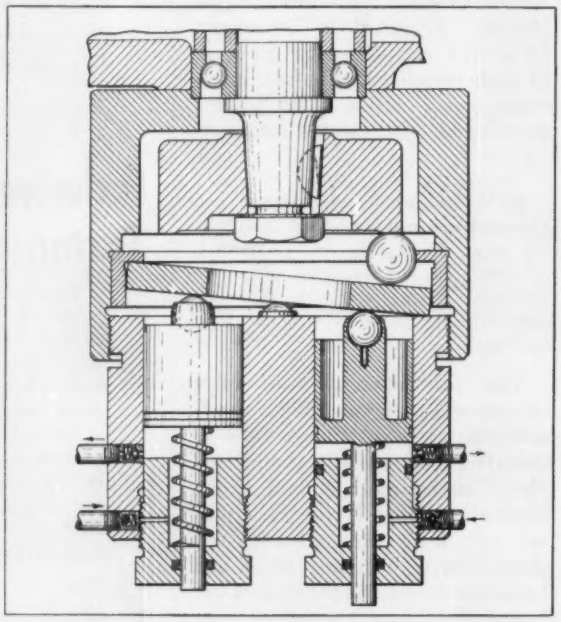
Patents

Rotary-to-Linear Motion Converter

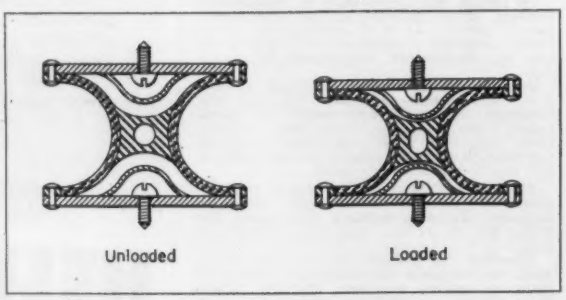
Speed reduction is provided in addition to motion translation by a ball drive in combination with a wobble-plate mechanism. The ball provides a planetary



action to give a 2:1 speed reduction between the driving plate and the wobble plate. *Patent* 2,913,911 *assigned to Bendix-Westinghouse Automotive Air Brake Co., Elyria, Ohio, by John E. Gilkey.*

3-D Shock Mount

Transmission of vibration or shock in all three planes is prevented or damped by an isolator consisting of a



curved sheet of elastic material in which steel cables are imbedded. The cables are fastened at each end to

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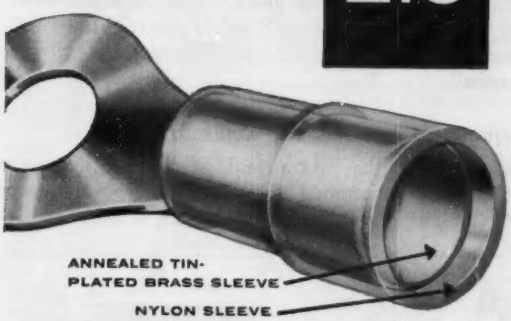

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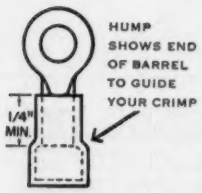

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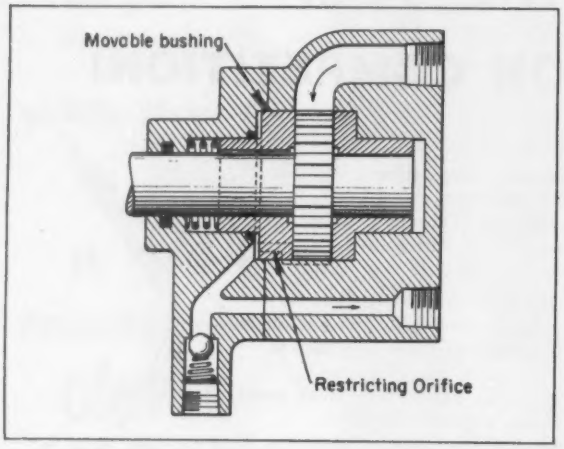
the rigid supporting members. A shock damper is placed between the convex faces of the curved elastic sheets. This damper controls the bend radii of the elastic sheets and acts against stops to control deflection of the mount under load. *Patent* 2,917,264 *assigned to Westinghouse Electric Corp., East Pittsburgh, Pa., by Raymond G. Hartenstein.*

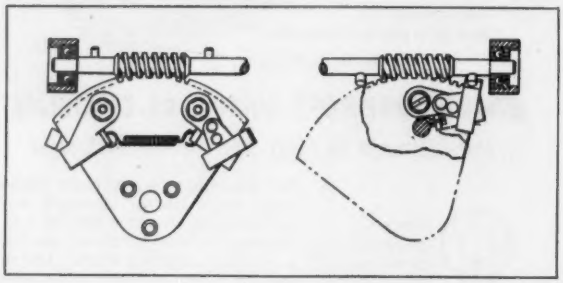
Constant-Flow Pump

Constant-volume output independent of rotary pump speed is provided by pressure-actuated movable bushings. Pump flow is discharged through a restricting orifice. The upstream pressure tends to force the bushings away from the gears. The downstream pressure, along with the loading springs, tend to force the bushings toward the gears. An increase in pump speed produces increased upstream pressure. At a predetermined value, the upstream pressure forces the bushings away from the gears. The increased clearance then regulates pump flow. *Patent* 2,915,977 *assigned to Borg-Warner Corp., Chicago, by John D. Campbell.*



Nonjamming Worm-Gear Limit Stop

Jamming of the worm and gear in a limit-stop mechanism is eliminated by stopping the worm rather than the gear. At the limit of travel, a lever on the gear contacts a stop pin. The lever pivots toward the worm, allowing a projection of the lever to engage a stop lug on the worm shaft. *Patent* 2,907,225 *assigned to Minneapolis Honeywell Regulator Co., Minneapolis, by Alvin W. Pischke.*



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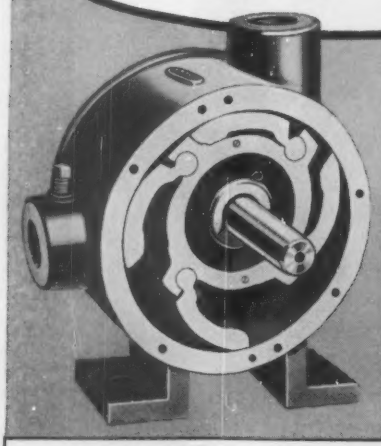

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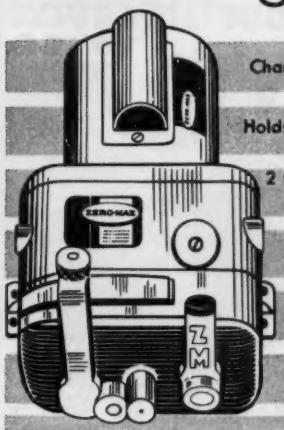

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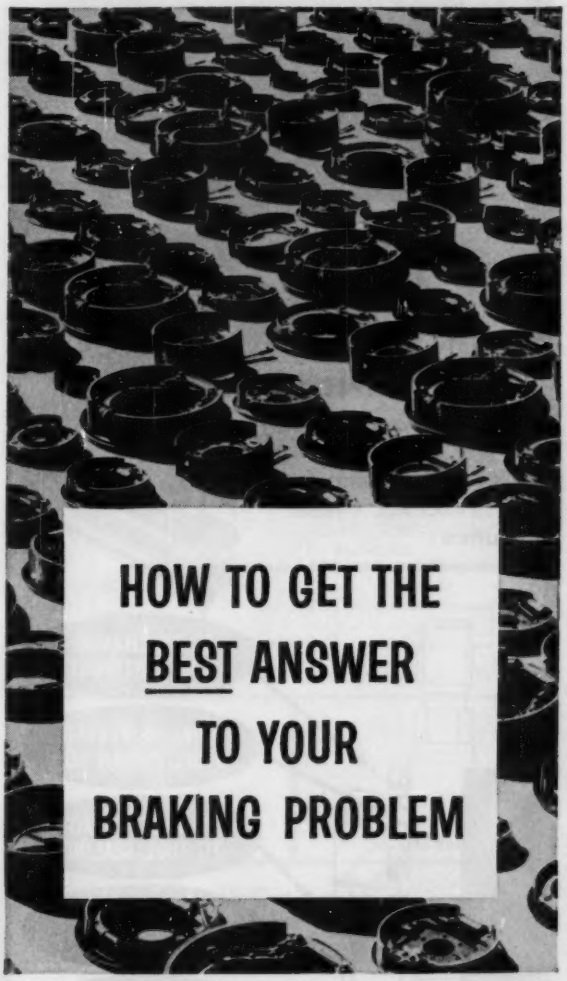

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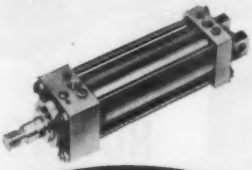

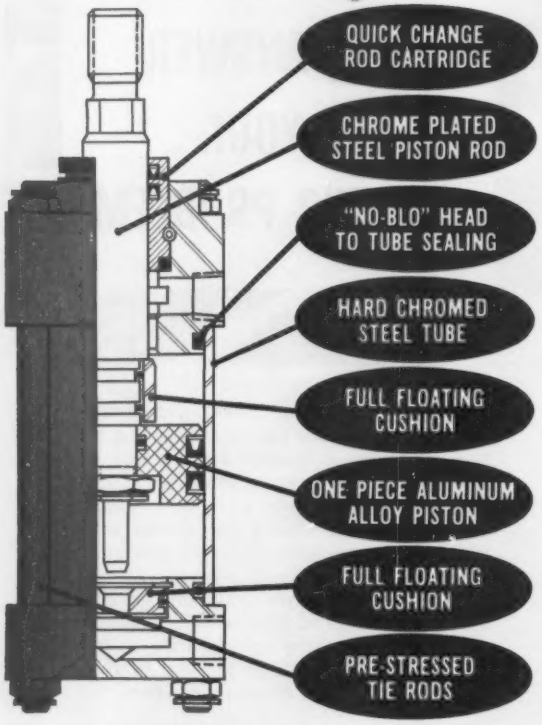
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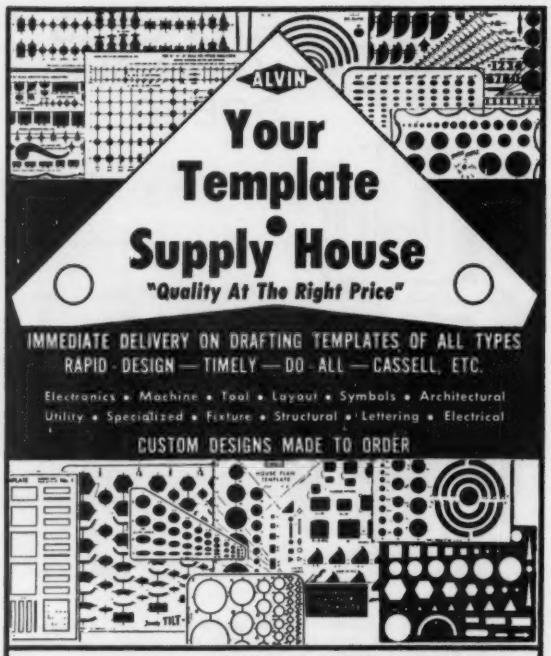
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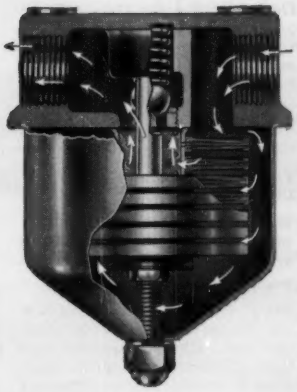

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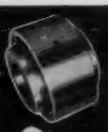

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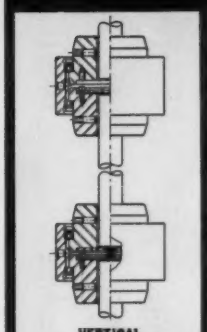

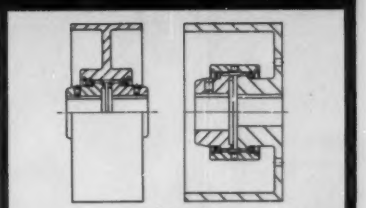

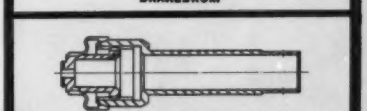

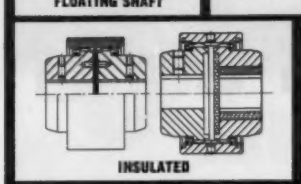

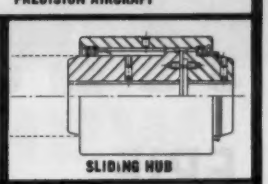

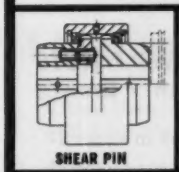

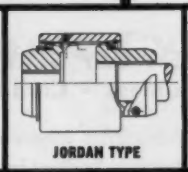

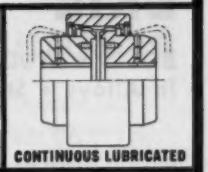

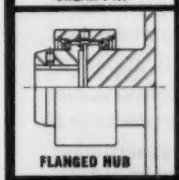

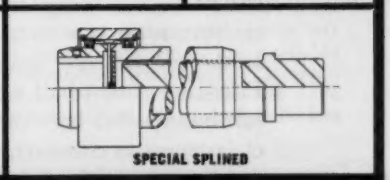

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Circle 578 on Page 19

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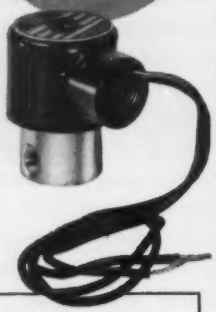

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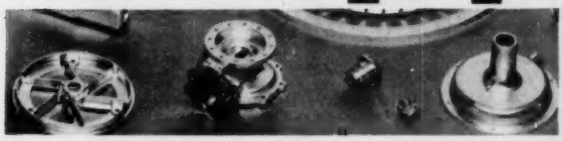

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Circle 582 on Page 19

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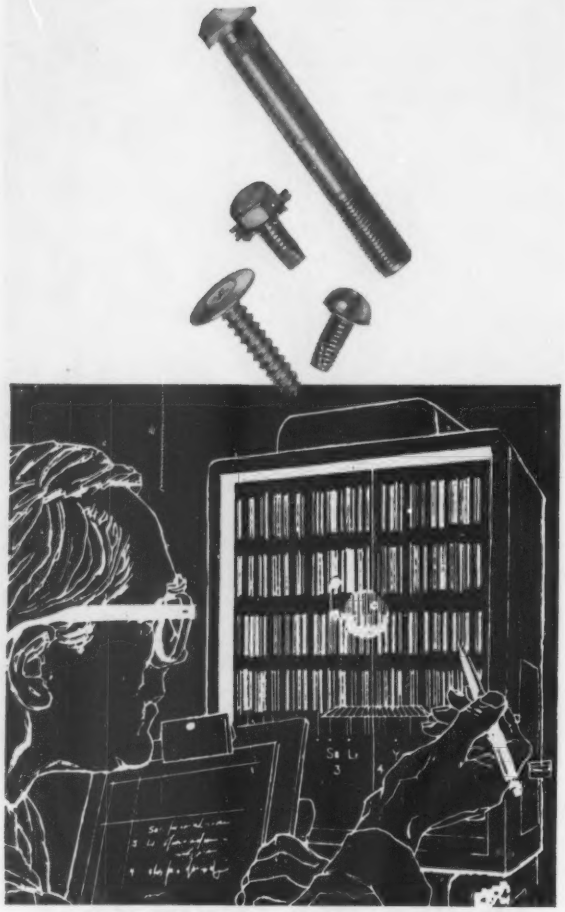
Circle 583 on Page 19



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0765	5.9	10	15	½	18
1065	8.3	25	30	1	33
2065	17.0	15	20	1½	52
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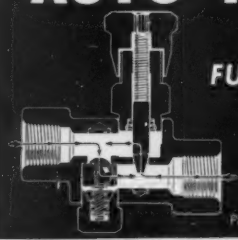

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Model PF Knob and Dial Flow Control Valve or Model PN Needle Valve for panel mounting.

Model C Check Valve for In-Line Mounting.

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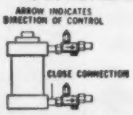
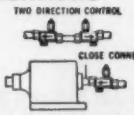


Controlling Double Acting Cylinder



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Advertising Index

Aetna Ball and Roller Bearing Co., Division of Parkersburg-Aetna Corporation 53
Air-Marine Motors, Inc. 192
Air-Maze Corporation 251
Ajax Flexible Coupling Co., Inc. 223
Alemite Division, Stewart-Warner Corporation 1
Allegheny Ludlum Steel Corporation, Carmet Division 65
Allen-Bradley Co. 97, 98
Allen Manufacturing Co. 204
Allis, Louis, Co., The 56, 57
Alvin & Co., Inc. 250
Amchem Products, Inc. 50, 51
American Cast Iron Pipe Co., Special Products Division 114
American Chain & Cable Co., Inc., Helicoid Gage Division 245
American Machine and Metals, Inc., United States Gauge Division 64
American Nickeloid Co. 55
AMP, Inc. 16
Ardmore Products, Inc. 240
Armstrong Cork Co., Industrial Division 68
Arwood Precision Casting Corporation 217
Automatic Electric 110
Auto-Ponents, Inc. 256

Barksdale Valves, Control Division 205
Bassick Co., The, Stewart-Warner Corporation 247
Bellofram Corporation 35
Bendix Aviation Corporation, Bendix Products Division 249
Bendix-Westinghouse Automotive Air Brake Co. 61, 62
Benton Harbor Engineering Works, Inc. 253
Borg-Warner Corporation, Borg-Warner Mechanical Seals Division 232
Borg-Warner Mechanical Seals Division, Borg-Warner Corporation 232
Bound Brook Oil-less Bearing Co. ....Inside Front Cover
Brown & Sharpe Mfg. Co., Hydraulics Division 176
Bruning, Charles, Co., Inc. 174, 175
Buffalo Forge Co., Buffalo Pumps Division .. 69
Bunting Brass and Bronze Co. 77

Cambridge Wire Cloth Co., The 104
Carlson, G. O., Inc. 33
Carpenter Steel Co., The 86
Century Electric Co. 70, 71
Channing Corporation, Nice Ball Bearing Co. Division 108
Chart-Pak, Inc. 198
Chatillon, John, & Sons 184
Chicago Rawhide Manufacturing Co., Sirvon Division 2
Cinch Manufacturing Co., Howard B. Jones Division 250
Clark Controller Co., The 5
Clippard Instrument Laboratory, Inc. 255
Clover Industries, Inc. 256
Colorado Oil and Gas Corporation, Marsh Instrument Co. Division 252
Commercial Shearing & Stamping Co. 100, 101
Copperweld Steel Co., Aristoloy Steel Division 11
Copperweld Steel Co., Ohio Seamless Tube Division 170
Corning Glass Works 179
Curtis Universal Joint Co., Inc. 242

Dana Corporation 191
Dayton Industrial Products Co., A Division of The Dayton Rubber Co. 99
Dayton Rubber Co., Dayton Industrial Products Co. Division 99
Denison, R. B., Mfg. Co. 236
Detroit Power Screwdriver Co. 203
Diamond Chain Co., Inc. 106
Dimco-Gray Co. 251
Dixon Sintaloy, Inc. 227
Dodge Manufacturing Corporation 48
Dollin Corporation 253
Dollinger Corporation 226
Drop Forging Association 183

Du Pont, E. I., de Nemours & Co., Inc. 63
Dynamatic Division, Eaton Manufacturing Co. 93

Eastman Kodak Co., Graphic Reproduction Division 173
Eastman Manufacturing Co. 177
Eaton Manufacturing Co., Dynamatic Division 93
Eaton Manufacturing Co., Reliance Division.. 193
Elastic Stop Nut Corporation of America 109
Erie Bolt & Nut Co. 252
ETC, Inc. 247

Falk Corporation, The 83
Fawick Corporation, Fawick Airflex Division .. 215

Gardner-Denver Co. 102
Gast Manufacturing Corporation 255
General American Transportation Corporation, Parker-Kalon Division 88
General Electric Co. 89
General Motors Corporation, Hyatt Bearings Division 84, 85
General Motors Corporation, Saginaw Steering Gear Division 105
Gits Bros. Mfg. Co. 111
Gleason Works 181
Globe Industries, Inc. 54
Goodrich Chemical, B. F., Co., A Division of The B. F. Goodrich Co. 82
Gray Iron Founders' Society, Inc. 229
Grip-Nut Co. 246

Handy & Harman 222
Hannifin Co., A Division of Parker-Hannifin Corporation 79
Hansen Manufacturing Co., Inc. 224
Haynes Stellite Co., Division of Union Carbide Corporation 47
Heim Co., The 212
Helicoid Gage Division, American Chain & Cable Co., Inc. 245
Hexcel Products, Inc. 260
Hi-Lo Manufacturing Co. 218
Horsburgh & Scott Co., The 220
Hubbell, Harvey, Inc. 242
Hyatt Bearings Division, General Motors Corporation 84, 85

Illinois Gear & Machine Co. 75
Industrial Clutch Corporation 244
Industrial Press, The 210
Industrial Tectonics, Inc. 15
International Basic Economy Corporation, Valvair Corporation 187
International Packings Corporation 31

Jones, Howard B., Division, Cinch Manufacturing Corporation 250
Joy Manufacturing Co. 189

Kayden Engineering Corporation, The 21
Keuffel & Esser Co. 91
Keystone Steel & Wire Co. 115

Laminated Shim Co., Inc., The 107
LaSalle Steel Co. 7
Leiman Bros., Inc. 248
Lindberg Air and Hydraulic Division, Teer-Wickwire & Co. 250
Linear, Inc. 209
Link-Belt Co. 29
Lisle Corporation 194
Lord Manufacturing Co. 60

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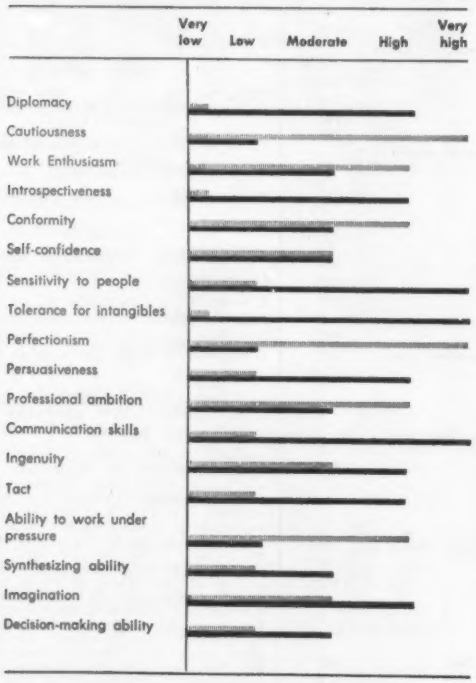
BPA NBP

backtalk—

—His and Hers

Response to our recent series, "The Engineer: Paragon or Paradox?" (Dec. 10, Dec. 24, and Jan. 7 issues) included a letter written on graph paper in a feminine hand. Mrs. M. N. Ross, commenting on the first article, which deals with personality, informed us that Mr. Ross—a "norm" engineer—was not especially interested in the article (low introspectiveness). She, on the other hand, was mightily interested in it, and explains this is because she is a typical engineer's wife. Mrs. Ross goes on to suggest that we do a survey on engineers' wives, predicting that such a survey would show that the ladies follow a personality pattern just as Mr. Raudsepp's article showed their husbands do. Below is a table which appeared with the article. Shaded bars show the male engineer's characteristics; solid bars indicate one engineer's wife's idea of characteristics of the average of her species.



Ruth Ross suggests the obvious conclusion: "An engineer appreciates his shortcomings and marries a girl who helps balance his own personality."

—Why Did You Go?

The next issue of MACHINE DESIGN will bring another article by Mr. Raudsepp, called "Why Engineers Work." It will include results of surveys made to determine what factors influence an engineer's choice of jobs and also suggest some reasons engineers quit their jobs.

This problem plagues all branches of industry and has, therefore, been studied by the American Management Association—with some interesting results from a new technique. "Post-terminal interviews," conducted some time after an employee has left a company, tend to reveal more accurate reasons for separation than the "exit interview" conducted at the time a person leaves. Minding his manners to the bitter end, an employee will usually give socially acceptable reasons for quitting. Returns from post-terminal questionnaires, however, are usually more blunt—and more reliable.

Engineers are perhaps distinguished by more accurate answers during their first interviews than most people. (See "Tact" line in the personality table.)

—Flight of Fancy?

An ornithopter, says our dictionary, is "a type of aircraft designed to be propelled by wing flapping, never proved practical." Perhaps the 1960 model ornithopter (Page 24) will break the impracticality barrier—if so, it's about time, because people have been flapping around unsuccessfully long enough.

Greek mythology indicates that the ornithopter principle was tried by Daedalus and his son Icarus, whose dramatic flight depended upon birds' feathers stuck together with wax.

Having the good sense to stay on the ground, men like Roger Bacon and Leonardo da Vinci also worked on the ornithopter problem. Bacon envisaged man flying a machine that would flap bird-like wings, and Da Vinci recommended studying the wing structure of bats.

Which brings us back to our contemporary ornithopter. Power remains a problem: It has been estimated that a pigeon the size of a man could exert about 3 hp, which is 20 or 30 times the average man's ability. Man may never fly like a pigeon, but if he flies by his own power, Icarus will not have died in vain.

Advertising Index

Lovejoy Flexible Coupling Co. 218
Lukens Steel Co. 78
Lyon Metal Products, Inc. 247

McGill Manufacturing Co., Inc. 238

Magnetic Amplifiers, Inc. 244
Marsh Instrument Co., Division of Colorado Oil and Gas Corporation 252
Meehanite Metal Corporation 235
Messinger Bearings, Inc. 243
Metals & Controls, A Division of Texas Instruments Inc. 231
Midland-Ross Corporation, Waldron-Hartig Division 230
Miniature Precision Bearings, Inc. 185
Minneapolis-Honeywell Regulator Co., Control Devices Division 46
Minnesota Mining and Manufacturing Co., Adhesives, Coatings and Sealers Division .. 233
Modernair Corporation 178
Monsanto Chemical Co., Plastics Division ..58, 59
Morganite, Inc. 239
Mulconroy Co. 259

National Lock Co., Fastener Division 254
National Screw & Mfg. Co., The 52
National-Standard Co. 38, 39
National Vulcanized Fibre Co. 40, 41
New Hampshire Ball Bearings, Inc. 237
New Jersey Zinc Co., The 116
Nice Ball Bearing Co., Division of Channing Corporation 108

Ohio Precision Castings, Inc. 256
Ohio Seamless Tube Division of Copperweld Steel Co. 170
Orange Roller Bearing Co., Inc. 207

Packard Electric 76
Parker Fittings and Hose Division, Parker-Hannifin Corporation 79
Parker-Hannifin Corporation, Hannifin Co. Division 79
Parker-Hannifin Corporation, Parker Seal Co. Division 228
Parker-Kalon, A Division of General American Transportation Corporation 88
Parkersburg-Aetna Corporation, Aetna Ball and Roller Bearing Co. Division 53
Parker Seal Co., A Division of Parker-Hannifin Corporation 228
Partlow Corporation, The 87
Perkins Machine and Gear Co. 234
Pheoll Manufacturing Co., Inc. .....Inside Back Cover
PIC Design Corporation 253
Precision Rubber Products Corporation 188
Protective Closures Co., Inc., Caplugs Division 225
Prudential Industries 43

Quinn-Berry Corporation 9

Reese Metal Products Corporation 210
Reliance Division, Eaton Manufacturing Co. 193
Reliance Electric and Engineering Co. 197
Robbins & Myers, Inc. 81, 211
Rockwell-Standard Corporation, Brake Division 113
Rockwell-Standard Corporation, Universal Joint Division 219
Rohm & Haas Co. 49
Rollway Bearing Co. 92
Rotherm Engineering Co., Inc. 255
Ruthman Machinery Co., The 196

Saginaw Steering Gear Division, General Motors Corporation 105
Sealol Corporation 202
Set Screw & Mfg. Co. 196
Sharon Steel Corporation 94, 95
Sier-Bath Gear and Pump Co., Inc., Flexible Coupling Division 251
SKF Industries, Inc. 72
S-P Manufacturing Corporation, The 216
Spectrol Electronics Corporation 218
Spencer Products, Metals & Controls, A Division of Texas Instruments Inc. 231
Sperry Rand Corporation, Vickers, Inc. Division 90
Sperry Rand Corporation, Vickers, Inc., Electric Products Division 241
Square D Co. 103
Standard Pressed Steel Co., Industrial Fastener Division 80
Stanpat Co. 194
Sterling Electric Motors, Inc. 112
Stewart-Warner Corporation, Alemite Division 1
Stewart-Warner Corporation, The Bassick Co. Division 247

Taylor Fibre Co. 66, 67
Teer-Wickwire & Co., Lindberg Air and Hydraulic Division 250
Texas Instruments Inc., Metal & Controls Division 231
Timken Roller Bearing Co., The .....Back Cover
Tomkins-Johnson Co., The 221
Torrington Co., The 13

Union Carbide Corporation, Haynes Stellite Co. Division 47
Union Carbide Corporation, Union Carbide Plastics Co. Division 73
Union Carbide Plastics Co., Division of Union Carbide Corporation 73
Unitcast Corporation 186
United States Gauge, Division of American Machine and Metals, Inc. 64
United States Graphite Co., The, Division of The Wickes Corporation 44, 45
Universal Joint Division, Rockwell-Standard Corporation 219

Valvair Corporation, Division of International Basic Economy Corporation 187
Vickers, Inc., Division of Sperry Rand Corporation 90
Vickers, Inc., Division of Sperry Rand Corporation, Electric Products Division 241
Vulcan Electric Co. 174

Waldes Kohinoor, Inc. 195
Waldron-Hartig Division, Midland-Ross Corporation 230
Wapakoneta Machine Co., The 200
Ward Leonard Electric Co. 74
Waterman Hydraulics Corporation 27
Watlow Electric Manufacturing Co. 42
Westinghouse Air Brake Co., Industrial Products Division 214
Wheelock, Lovejoy & Co., Inc. 206
White, S. S., Industrial Division 208
Whitney Chain Co., The 213
Wichita Clutch Co., Inc. 201
Wickes Corporation, The, United States Graphite Co. Division 44, 45
Wiegand, Edwin L., Co. 198, 199
Wolverine Tool Co. 249
Wood's, T. B., Co. 36, 37
Wyman-Gordon 96

Zero-Max Co., The 249

Engineers Available or Wanted 256

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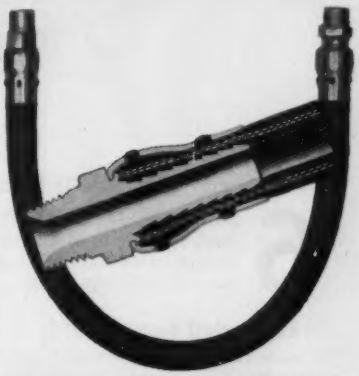

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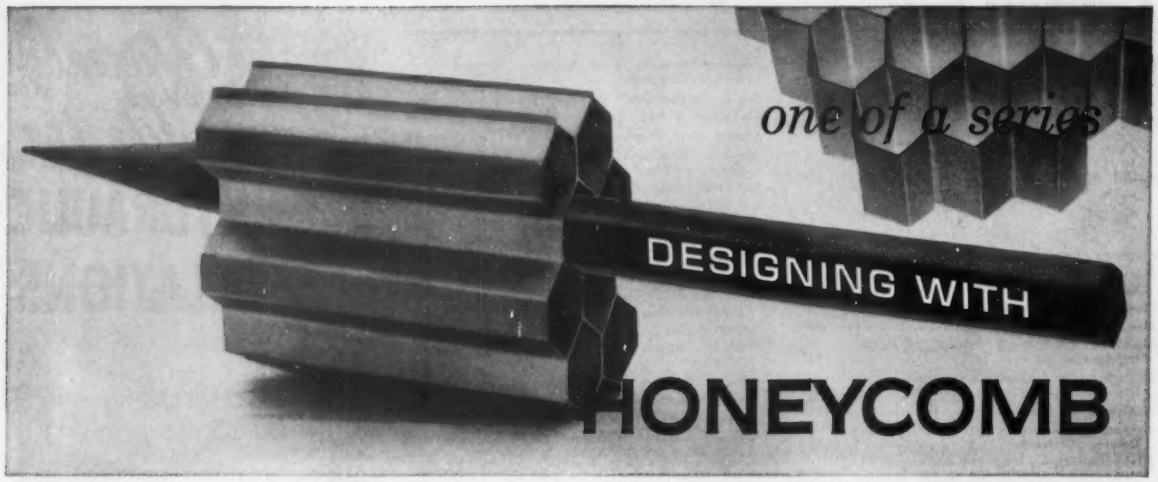
Circle 591 on Page 19



THE VARIETIES OF HONEYCOMB

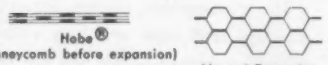
#6 CELL GEOMETRY The cell geometry, or configuration, of honeycomb is determined during manufacturing by the basic method of production. Two honeycomb production techniques are in use today: expansion and corrugation.

Expanded Honeycomb

The material for the honeycomb—preimpregnated fiber glass cloth, aluminum alloy foil, paper, or other web materials—is fed from rolls into special high-precision machinery, where continuous stripes of structural adhesives are applied to the web. This web is then folded or cut into sheets and stacked in such a manner that the resulting bonded stack can be expanded to form hexagonal cells. Before expansion the stack is cured to set the node bond adhesive.

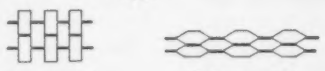
Figure 1 illustrates a stack, called HOBE® for HOneycomb Before Expansion, in a compressed condition and the resultant geometry under normal expansion.

Fig. 1



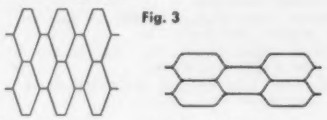
Expansion is normally stopped when the characteristic hexagonal-shaped cells are formed. By varying the degree of expansion from partial expansion to full overexpansion, virtually unlimited adjustment of the web area to volume relationship may be obtained. Figure 2 illustrates variations in cell geometry resulting from controlled expansion.

Fig. 2



By varying the width and location of the adhesive stripes, a number of other cell configurations are possible, such as those shown in Figure 3.

Fig. 3

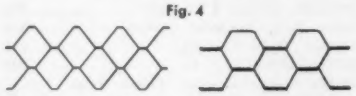


Corrugated Honeycomb

The material for corrugated honeycomb—aluminum alloy, stainless steel, titanium, and others—is pre-corrugated to the desired configuration. Precision equipment then joins the corrugated material at the node point with a resistance weld or an adhesive connection.

The corrugating technique is used principally for welded honeycomb products with the characteristic square-cell configuration shown in Figure 4. Corrugation is also adaptable to materials, foil gauges, or adhesive systems that do not lend themselves to the expansion process.

Fig. 4



MATERIALS The designer can call upon an extremely wide range of honeycomb materials to meet individual design problems.

Metallic Honeycombs

In standard production are aluminum alloys 3003 and 5052 and such stainless alloys as 17-7PH, PH15-7Mo, AM 350 and 355. Special production includes aluminum alloy 5056, a wide variety of stainless alloys, and exotic metals such as tantalum, molybdenum and titanium. Experimental work also continues on copper and carbon steel.

Non-Metallic Honeycombs

In standard production are non-impregnated Kraft paper and glass-fabric impregnated with phenolic resins, polyester resins and special heat-resistant phenolics. Special production includes phenolic impregnated Kraft paper and impregnated asbestos webs. In addition, experimental work continues on silicone, phenylsilane, rubber, and a number of sheet plastics.

Sizes and Shapes

Standard production cell sizes vary from 1/8" to 1½". Core materials have been produced with cell sizes as small as 1/32" and as large as 3". Cell depths up to 24" and piece sizes up to 48" x 96" are available in some materials. Available in flat panels of close tolerance thickness or block form, as well as finished carved and contoured core assemblies, honeycomb offers a broad variety of configurations, materials, sizes and shapes to open even broader areas of potential application.

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Circle 592 on Page 19

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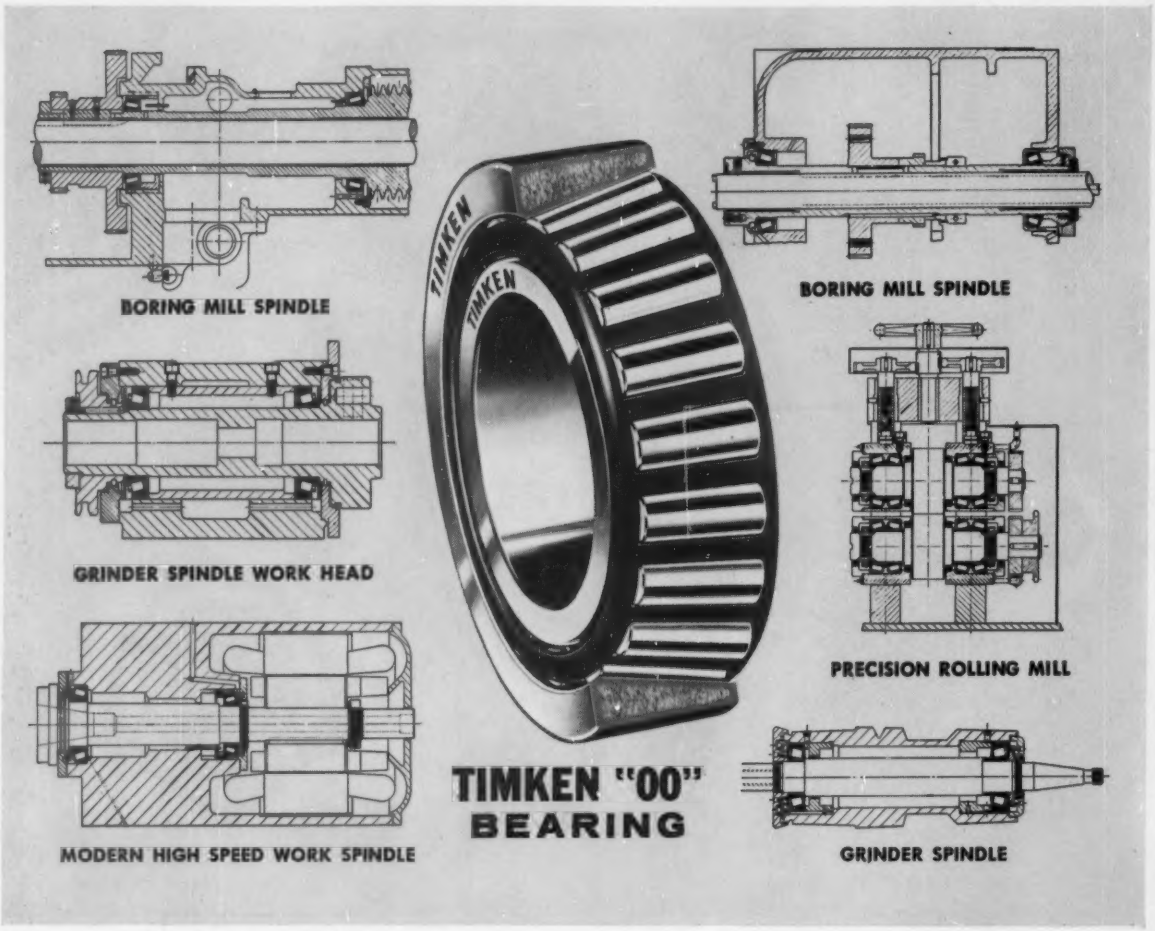
Circle 402 on Page 19



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Circle 403 on Page 19